SEP 75

TF 2361

Sweep Generator

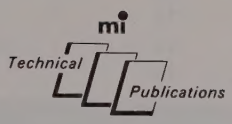
INSTRUCTION MANUAL

MP MASTER
MA30925

MARCONI INSTRUMENTS

Instruction Manual
No. EB 2361
for

Sweep Generator
TF 2361



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ST. ALBANS HERTFORDSHIRE ENGLAND

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Chapter 1

General information

1.1 INTRODUCTION

The TF 2361 Sweep Generator is a general-purpose instrument with a wide range of applications. The main unit, described in this manual, generates a sweep voltage which is used to drive a plug-in oscillator; several different plug-in oscillators are available, covering different frequency ranges, and each oscillator is described in a separate manual. The main unit houses the power supplies for the complete instrument, and has front panel controls which enable the sweep voltage to be driven internally or externally, locked to the mains frequency or to a television frame scan, or controlled manually. Other facilities include a blanking generator, a marker adder and an X-drive output for an associated oscilloscope, display unit or chart recorder.

The operational modes are selected by a front panel sweep function switch. This gives a range of internal sweep drive from 0.01 Hz to 100 Hz in four decades, mains lock to mains frequencies from 45 to 400 Hz, TV lock to frame scan on 405, 525 or 625 line composite television signals, external control by signals from d.c. to 20 kHz, a c.w. mode in which the instrument behaves as an ordinary signal generator, and a manual mode in which a control is used to manually sweep over the range of frequencies set up on the plug-in oscillator. The ratio of sweep to flyback can be set at 1:1 or 10:1, and on the internal ranges the instrument can be set to give a single sweep when a 'one shot' switch is operated.

In the mains lock and TV modes, a phase shift control allows the swept frequency to be positioned so that high or low frequencies are applied to any part of the spectrum being examined.

The instrument is contained in a bench mounting case, or it can be rack mounted.

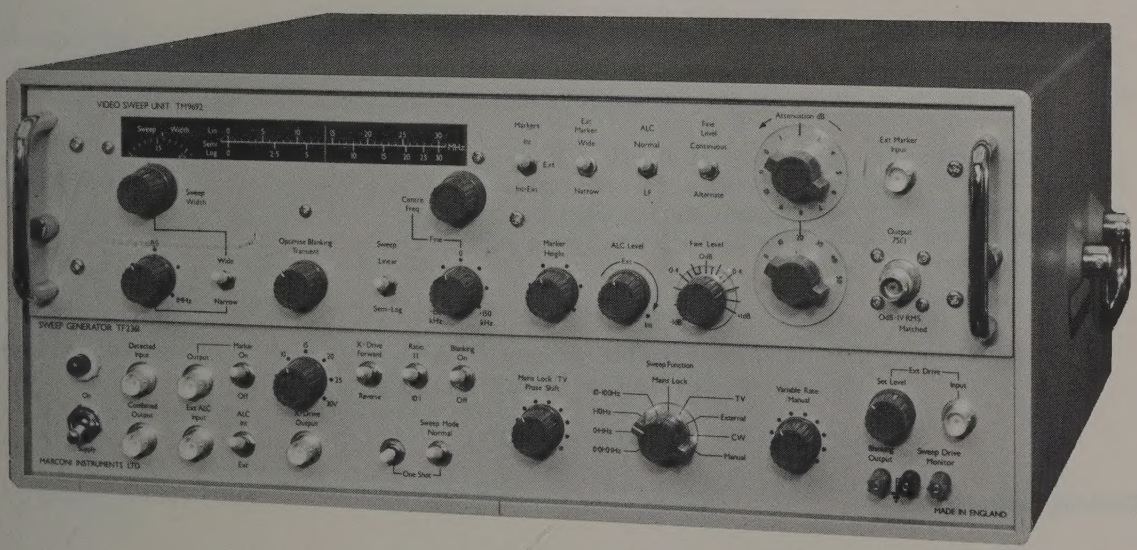


Fig. 1.1 Sweep generator TF 2361, fitted with video oscillator TM 9692

1.2 DATA SUMMARY

Characteristics	*Performance*	*Supplementary information*
Internal sweep		
Ranges:	0.01 to 0.1 Hz 0.1 to 1.0 Hz 1.0 to 10 Hz 10 to 100 Hz	
Rate control:	Continuously variable over selected range.	
Sweep ratio:	Ramp : Nominal 10:1. Triangular : Nominal 1:1.	
Single sweep:	Provided on all ranges 0.01 to 100 Hz, frequency adjustable by variable rate control.	
Locked sweep		
Mains lock:	Locks to 50, 60 or 400 Hz mains frequencies, according to position of variable rate control; at 400 Hz, lock is to sub-multiple within range 40-65Hz.	
Phase shift:	Adjustable up to 270^{o} phase shift on mains lock and TV field lock only.	
External TV field:	Locks on 405, 525 and 625 line systems. Variable rate control available.	
TV input required:	Composite signal: 1 V p-p (approx. 0.3 V sync pulses). Negative field pulses: 0.3 V to 3 V. Sine wave: 5 V to 10 V p-p.	
Input impedance:		75 Ω nominal.
Waiting time:	Minimum time for stability on mains lock and TV field lock not greater than 500 μs.	
Blanking output		
Amplitude:	Greater than +22 V from 2 kΩ source.	
Rise time:	Less than 4 μs, 10-90%.	
Decay time:	Less than 20 μs, 10-90%.	

Characteristics	Performance	Supplementary information
X-Drive		
Output:	D.C. coupled, reversible.	
Amplitude:	Continuously variable up to at least 30 V p-p into 50 kΩ impedance (2 V p-p into 1 kΩ impedance). Symmetrical about earth.	
A.L.C.		Internal, or external with suitable a.l.c. detector for the sweep unit.
Marker adder		Detected signal added to the marker output to provide combined marker and signal output.
External sweep		
Sensitivity:	Adjustable.	
Minimum input:	4.5 V p-p sine wave drive, symmetrical about earth, for full sweep.	
Maximum input:		50 V p-p sine wave drive, symmetrical about earth.
Bandwidth:	D.C. to 20 kHz.	
Manual sweep		Gives full sweep range of the plug in sweep unit within the limits of the close sweep width.
C.W. output		Provides a c.w. signal at any frequency of the sweep range. Adjustable centre frequency control on sweep unit.
Power requirements		
A.C. mains input:	95 to 130 V or 190 to 264 V, 45 to 65 Hz; 105 to 130 V or 200 to 264 V, 65 to 500 Hz.	
Power consumption:	40 VA with plug-in unit.	

Dimensions and weight	Height	Width	Depth	Weight
	178 mm (7 in)	432 mm (17 in)	406 mm (16 in)	9.1 kg (20 lb)

1.3 ACCESSORIES

Description	M.I. code
Accessories supplied	
Kit, comprising :	46883-060
Free Plug type BNC (3 off)	23443-374 / 23443-371
Adapter 2 mm to BNC	43168-015
Mains Lead	43122-017
Optional accessories	
Extension Cable TM 9912 To allow operation of a plug-in unit when removed from the main unit for repair or maintenance.	43127-066
Rack Mounting Kit TM 8270	46883-002
Associated equipment	
Video Sweep Unit TM 9692 25 kHz to 30 MHz.	52362-013
VHF Sweep Unit TM 9693 1 MHz to 300 MHz.	52363-013
UHF Sweep Unit TM 9694 220 MHz to 1000 MHz.	52364-013
VHF/UHF Attenuator TM 9695 For use with TM 9693 and TM 9694.	46845-104

Chapter 2

Operation

2.1 INSTALLATION

The instrument, when contained in a bench cabinet, is ready for immediate operation after the plug-in unit has been fitted in position and the supply voltage adjusted and connected. The supply lead is stowed on cleats at the rear of the case, and a hinged bar under the case permits the instrument to be tilted at an angle convenient for operation of the front panel controls. The operation of the instrument depends on the plug-in unit in use, and all operating procedures for the complete equipment are described in the manual for the plug-in unit.

Rack mounting arrangements

The instrument can be removed from its case and rack mounted using the rack mounting accessory kit available as an optional accessory. The instrument can be withdrawn from its case when the four 2 BA screws at the rear are removed, and the rack mounting brackets can then be fitted on each side of the main chassis. Slides or runners should be used to carry the weight of the instrument.

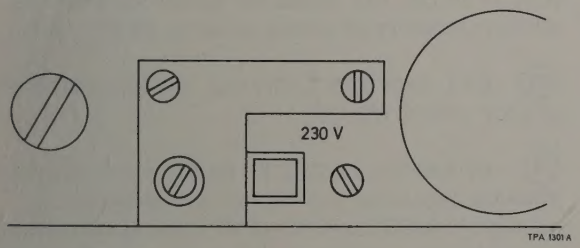


Fig. 2.1 A.C. supply range switch

Supply voltage adjustment

The instrument can be operated from a. c. mains supplies of 95 to 130 V or 190 to 264 V. Selection of the appropriate range is made by a two-position sliding switch at the rear of the case, which can only be moved from one position to another when a locking plate is removed (two 6 BA screws). Reverse the plate and re-secure it to lock the switch in its new position. The two ranges (115 V and 240 V) are engraved on the rear panel, and the range in use is visible through the cut-out section of the locking plate.

Mains lead

Attach a suitable 3-pin plug to the mains lead. The colour code used for the wires is being changed to conform to international standards; either of the following codes may apply to this instrument:

Earth	Green/yellow		Green/yellow
Neutral	Light blue	or	Black
Line	Brown		Blue

In addition the earth wire carries a yellow sleeve bearing a green earth symbol, and the neutral wire carries a sleeve marked N.

Fuses

Check that the rear panel fuses FS1 and FS2 in the a. c. supply are correctly rated for the a. c. supply range in use; 500 mA for the 95 to 130 V range, 250 mA for the 190 to 264 V range.

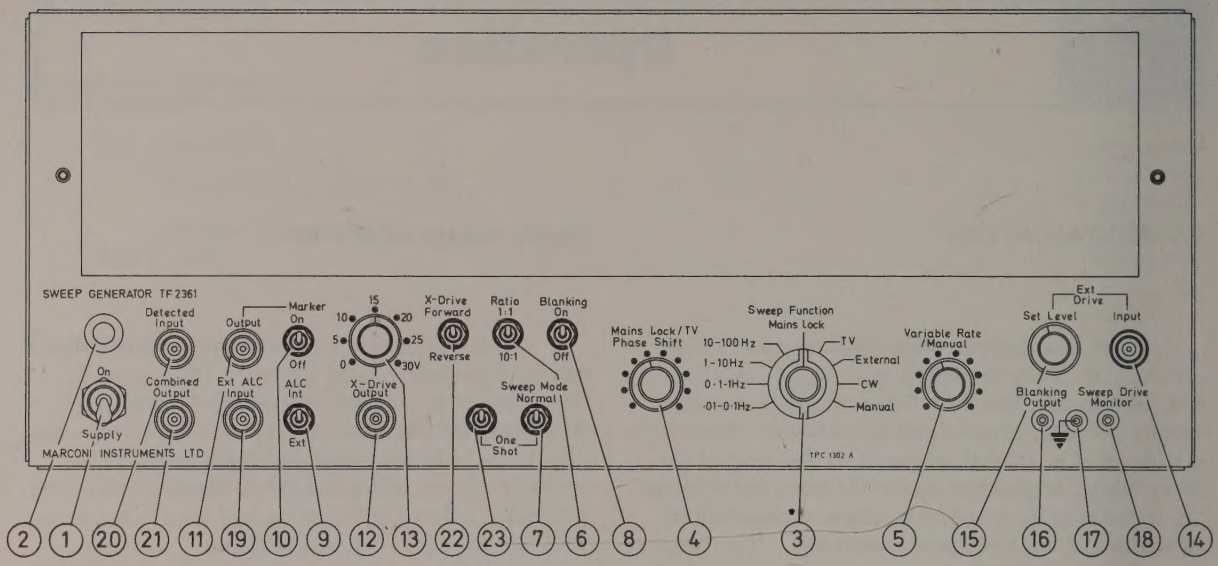


Fig. 2.2 Front panel controls and connectors

2.2 CONTROLS AND CONNECTORS

Front panel

(1) SUPPLY: A.C. mains on/off switch.

(2) SUPPLY INDICATOR LAMP: Lamp will glow when supply is switched ON.

(3) SWEEP FUNCTION: Sets the sweep generator to any one of nine operational modes.

(4) PHASE SHIFT: Varies the phase of the sweep output over a range of at least 270 ^{o} with respect to the input trigger in mains lock or TV mode.

(5) VARIABLE RATE: Gives continuous variation over selected range on internal sweep modes, and sufficient control in mains lock and TV modes to cover mains frequencies from 45 to 400 Hz and TV systems of 405, 525 or 625 lines. When 3) is set to MANUAL, this control can be used to give manual sweep.

(6) RATIO: Selects a ratio of sweep to flyback at either 1:1 or 10:1. Affects video output, blanking output and X-drive output.

(7) SWEEP MODE: In ONE SHOT position, brings one shot switch 23) into operation.

(8) BLANKING: With blanking on, the video output is turned off during the sweep flyback. This provides a convenient base line for the display.

(9) A.L.C. SWITCH: Switches a.l.c. from internal control to control from external a.l.c. detector via socket 19).

(10) MARKER SWITCH: Switches marker output from plug-in unit to combined output socket 21) and marker output socket.

(11) MARKER OUTPUT: Markers direct from plug-in unit, via switch (10).

(12) X-DRIVE OUTPUT: Provides horizontal sweep for associated oscilloscope or recorder, synchronized with sweep rate.

(13) X-DRIVE LEVEL CONTROL: Sets X-drive output level from 0 to 30 V p-p into 50 kΩ load, or from 0 to 2 V p-p into 1 kΩ load.

(14) EXT DRIVE INPUT: An input signal from d.c. to 20 kHz will sweep the generator when the SWEEP FUNCTION switch is set to EXTERNAL.

(15) EXT DRIVE SET LEVEL: Adjusts sensitivity of EXT DRIVE INPUT.

(16) BLANKING OUTPUT: Square wave output of blanking generator (1:1 or 10:1 according to position of RATIO switch) of 22 V for synchronizing or triggering associated equipment. Synchronized with sweep rate.

(17) EARTH SOCKET:

(18) SWEEP DRIVE MONITOR: Monitors the swept output from distorter and drive unit in plug-in.

(19) EXT A. L. C. INPUT: Automatic level control from external a. l. c. detector via A. L. C. switch (9)

(20) DETECTED INPUT: Accepts input from the detector in use so that markers may be added.

(21) COMBINED OUTPUT: Combination of detected input and markers (with MARKER switch ON).

(22) X-DRIVE SWITCH: To suit the polarity requirements of an associated oscilloscope or recorder connected to the X-drive output, the output horizontal sweep waveform may be either positive-going when the switch is set to FORWARD or negative-going when set to REVERSE.

(23) ONE SHOT: Spring-loaded switch, operational with SWEEP MODE in ONE SHOT position, triggers sweep for one cycle when released.

Rear panel

(24) SUPPLY SOCKET: 3 pin a. c. mains supply input connector.

(25) SUPPLY RANGE: 2 way switch with locking device, 95 to 130 V or 190 to 264 V.

(26) MAINS: Supply fuses 500 mA or 250 mA.

(27) -24 V: Supply fuse 1 A, time-lag.

(28) +24 V: Supply fuse 1 A, time-lag.

(29) +110 V: Supply fuse 160 mA, time-lag.

2.3 OPERATING INSTRUCTIONS

All other operational information, including control functions, switching-on procedure, operation and applications is given in the instruction manual for the plug-in unit.

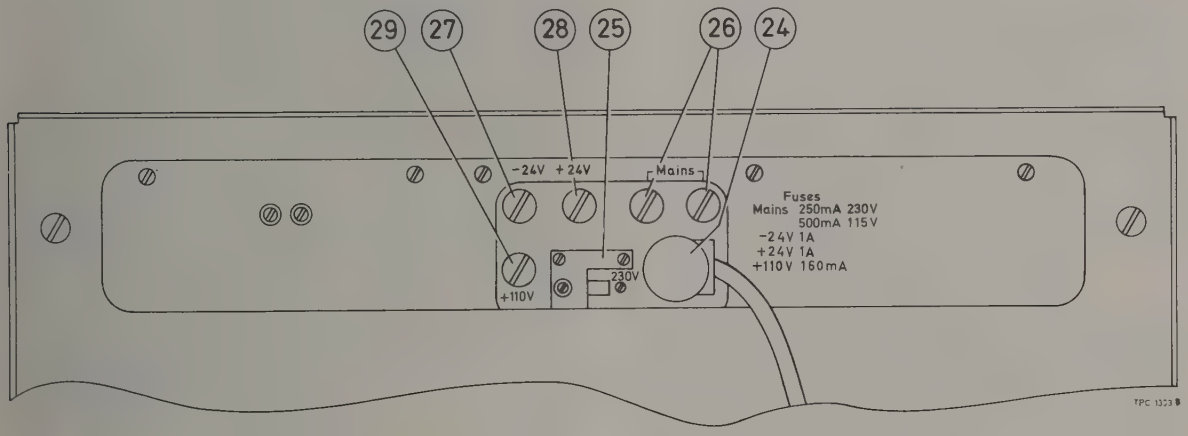


Fig. 2.3 Rear panel controls and connectors

Chapter 3

Technical description

3.1 GENERAL

The following technical description should be read in conjunction with the block diagram, Fig. 3.1, and the circuit diagrams included at the end of this manual.

3.2 CONTROL OSCILLATOR

(Circuit diagram, Fig. 7.2)

The control oscillator generates the sweep voltage used to drive the swept oscillator in the plug-in unit. The essential characteristics of the control oscillator are good linearity over a wide range of frequencies and rapid response to changes in frequency.

The oscillator comprises an emitter-coupled multivibrator with constant-current charging circuits; the current is varied to effect frequency control. Range selection of the four internal ranges and the mains lock/TV ranges is made by switching the capacitors C10 to C18 between the emitters of VT3 and VT5. Close coupling between these two transistors is provided in the feedback circuits by the Zener diodes MR5 and MR12 driven by the emitter followers VT1 and VT6.

Variation of frequency over any selected range is provided by the front panel variable rate control which changes the base voltages on VT2 and VT4. Minimum current at the lower end of the frequency range is preset by RV3 in the internal modes; in mains lock and TV modes, the minimum current is established by R8. The variable rate control gives overlap on the four internal sweep ranges, and gives sufficient control on the mains lock and TV ranges to cover mains frequencies from 45 to 400 Hz and TV systems of 405, 525 and 625 lines.

The multivibrator circuit generates two complex waveforms at the emitters of VT3 and VT5 respectively (see Fig. 3.2); the ramp portion of the VT3 waveform establishes the sweep voltage, while the ramp portion of the VT5 waveform establishes the flyback voltage. The ratio of sweep to flyback can be set at 10:1 or 1:1 by operation of the front panel ratio switch 10Sa, which changes the ratio of the collector current shared by VT12 and VT13.

VT1 provides a square wave output for operation of the blanking generator, and VT6 provides a squarewave output for resetting the binary VT15 in the sync trigger circuit.

Parasitic oscillation is prevented, in the external, c.w. and manual modes of operation, by R20 and R21, while R22, C9 and MR13 establish correct starting conditions. MR14 ensures that the correct starting conditions are not lost in the event of failure of the +24 V line.

The sweep and flyback outputs from the control oscillator pass through the sweep function switch in positions 1 to 6 (that is, the four internal ranges, mains lock and TV) before going to the differential amplifier. In the other three positions (external, c.w. and manual) the control oscillator is inoperative. During mains lock and TV operation, the control oscillator is locked to the mains or TV frame frequency by a trigger signal from the sync trigger circuit.

3.3 DIFFERENTIAL AMPLIFIER

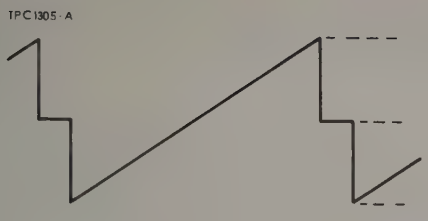
(Circuit diagram, Fig. 7.2)

The differential amplifier forms part of the control oscillator sub-unit, and combines the sweep and flyback signals from the control oscillator to form a single sweep output suitable for driving the plug-in unit. This output is held within precise current limits by preset gain and balance potentiometers so that no changes take place when different plug-in units are employed. The differential amplifier also supplies a current drive to the X-drive amplifier.

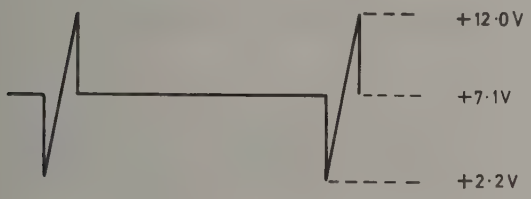
In the external, c.w and manual modes of operation the differential amplifier receives its inputs from the external drive amplifier sub-unit.

The emitter followers VT7 and VT11 are used as input buffers, and the current output from VT10 is set to sweep from 0.45 mA to 4.55 mA by RV1 (mean current value) and RV2 (current swing); this output is the current drive to the swept oscillator in the plug-in unit. The current output from VT8 is at a higher level, and supplies the input to the X-drive amplifier. These output waveforms are also shown in Fig. 3.2.

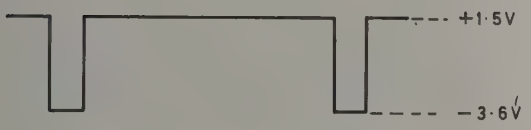
In the external and manual modes of operation RV1 (mean current value) is replaced by separate



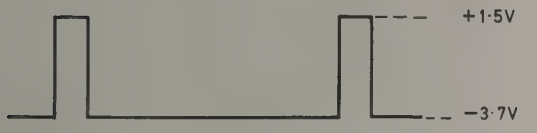
Control oscillator output tag 20 (sweep)



Control oscillator output at pin 21 (flyback)



Blanking output at pin 11

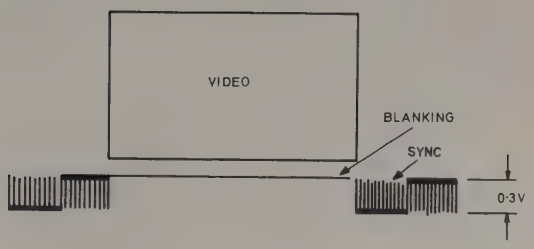


Reset output at pin 12

Output to X-drive amplifier at pin 29

Sweep output to plug-in at pin 30

Fig. 3.2 Operation of control oscillator on internal sweep modes (ratio 10:1)



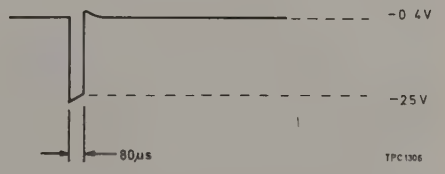
Composite TV signal at pin 1

Input to base of VT1

Output at VT1 collector

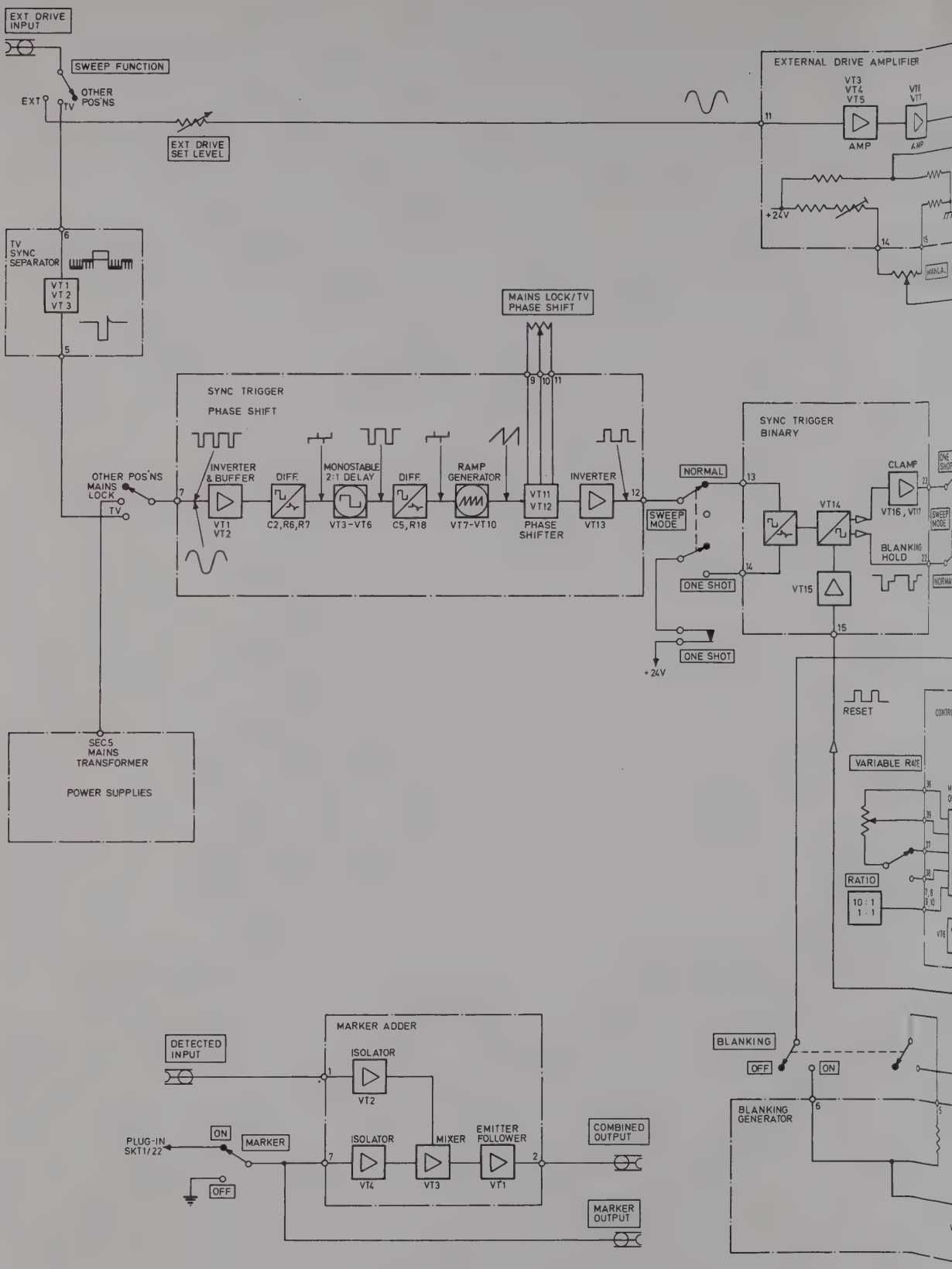
Input to base of VT2

Input to base of VT3



Output of VT3 at pin 5

Fig. 3.3 Operation of TV sync separator


EXT DRIVE INPUT
SWEEP FUNCTION
EXT
OTHER POS'NS
TV
EXT DRIVE SET LEVEL
EXTERNAL DRIVE AMPLIFIER
VT3 VT4 VT5
AMP
VT6 VT7
AMP
+24V
11
14
15
MAN.L.A.
TV SYNC SEPARATOR
VT1 VT2 VT3
6
5
MAINS LOCK/TV PHASE SHIFT
9
10
11
SYNC TRIGGER PHASE SHIFT
OTHER POS'NS
MAINS LOCK
TV
7
INVERTER & BUFFER
VT1 VT2
DIFF.
C2,R6,R7
MONOSTABLE 2:1 DELAY
VT3-VT6
DIFF.
C5,R18
RAMP GENERATOR
VT7-VT10
VT11 VT12
PHASE SHIFTER
INVERTER
VT13
12
NORMAL
SWEEP MODE
ONE SHOT
+24V
SYNC TRIGGER BINARY
13
14
15
VT14
VT15
CLAMP
VT16, VT17
BLANKING HOLD
23
22
ONE SHOT
SWEEP MODE
NORMAL
SEC.5 MAINS TRANSFORMER
POWER SUPPLIES
RESET
VARIABLE RATE
RATIO
10 : 1
1 : 1
36
39
37
38
7,8,9,10
VT6
MARKER ADDER
DETECTED INPUT
ISOLATOR
VT2
1
PLUG-IN SKT1/22
ON
MARKER
OFF
ISOLATOR
VT4
MIXER
VT3
EMITTER FOLLOWER
VT1
7
2
COMBINED OUTPUT
MARKER OUTPUT
BLANKING
OFF
ON
BLANKING GENERATOR
6
5

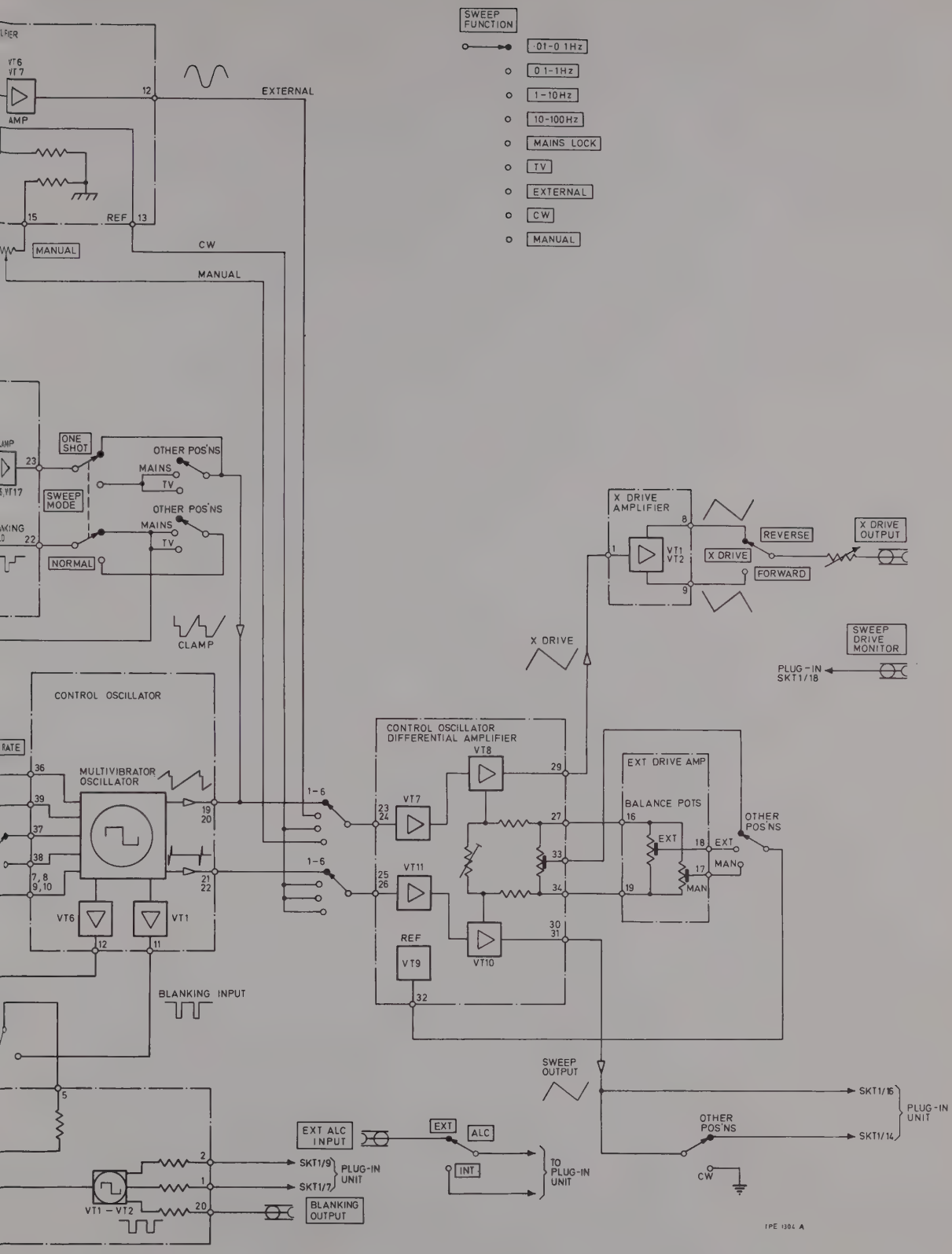
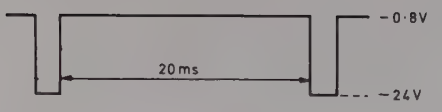
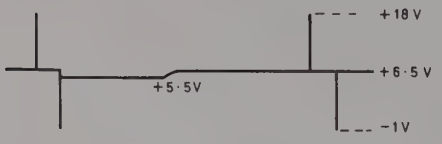


Fig. 3.1 Sweep generator TF 2361, block diagram

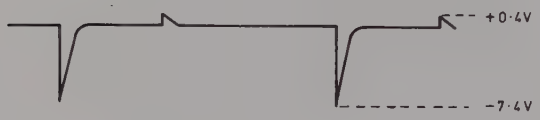


Input to sync trigger circuit pin 7



Differentiated input to phase shift 2:1 generator

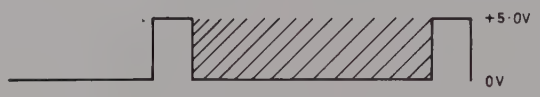
2:1 generator VT3 collector output



Differentiated input to ramp generator VT7

Ramp output from VT7 collector

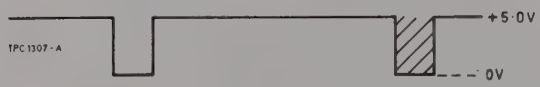
Ramp output from RV3 slider



Phase shift output pin 12 (control fully counter-clockwise)

Phase shift VT12 collector (control fully counter-clockwise)

Phase shift VT12 collector (control fully clockwise)



Phase shift output pin 12 (control fully clockwise)

Fig. 3.4 Operation of sync trigger and phase shift circuit (ratio 10: 1)

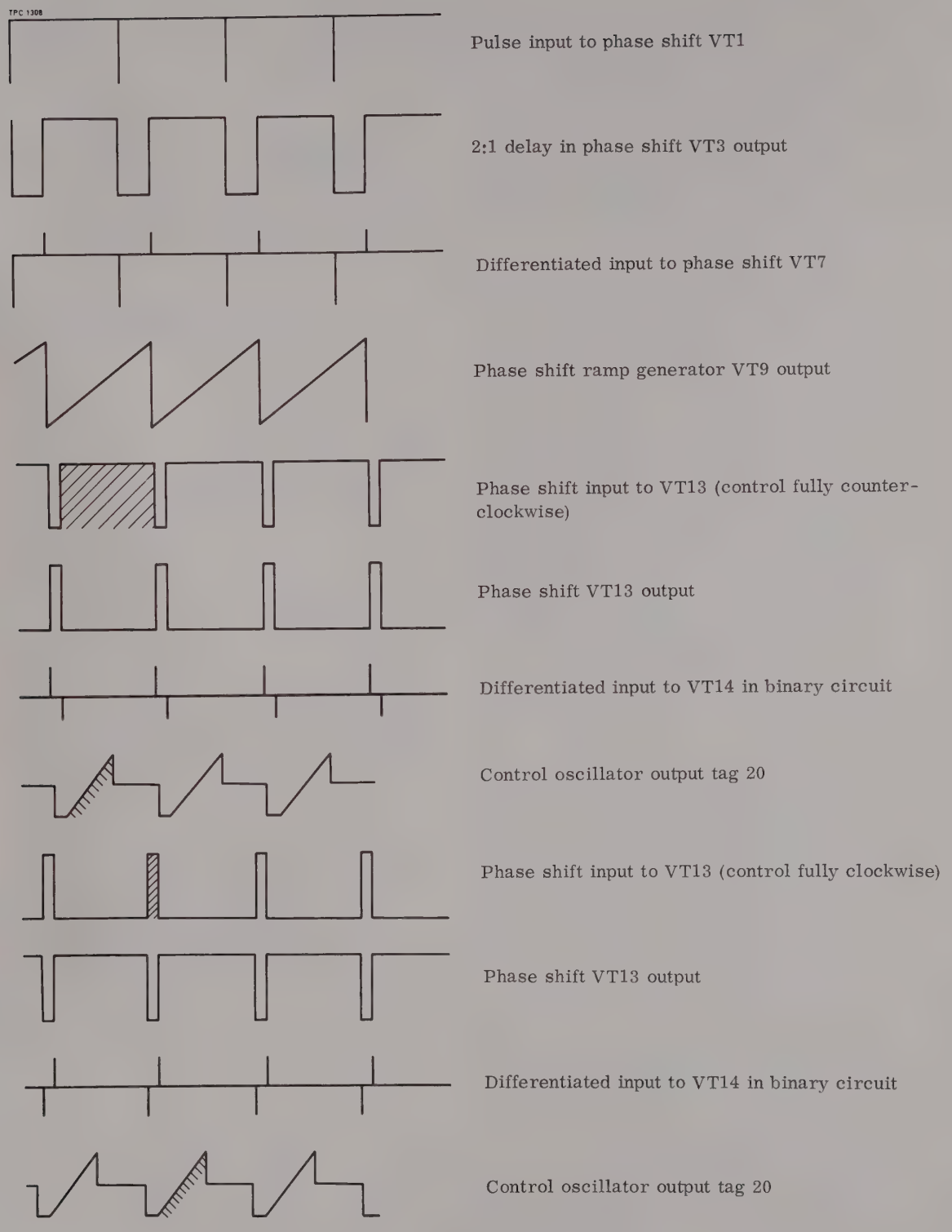

TPC 1308
Pulse input to phase shift VT1
2:1 delay in phase shift VT3 output
Differentiated input to phase shift VT7
Phase shift ramp generator VT9 output
Phase shift input to VT13 (control fully counter-clockwise)
Phase shift VT13 output
Differentiated input to VT14 in binary circuit
Control oscillator output tag 20
Phase shift input to VT13 (control fully clockwise)
Phase shift VT13 output
Differentiated input to VT14 in binary circuit
Control oscillator output tag 20

Fig. 3.5 Sync trigger and phase shift waveforms relative to control oscillator output (ratio 1 : 1)

Fig. 3.4

preset balance potentiometers in the external drive amplifier sub-assembly. VT9 supplies a constant current reference to each of these three potentiometers.

With the sweep function switch set to c.w., the output of the control oscillator is earthed, and the frequency output of the instrument is under the control of the centre frequency control on the plug-in. To keep the differential amplifier properly loaded in this non-operational state, a constant voltage is applied to both differential amplifier inputs from a potential divider on the external drive amplifier sub-unit.

With the sweep function switch set to manual, one side of the differential amplifier is fed from the reference supply in the external drive amplifier (the same as that used for c.w. operation) while the other side of the differential amplifier is supplied from the slider of the manual section of the variable rate/manual control. Preset balance and gain controls in the external drive amplifier determine the operating limits of the differential amplifier in the control oscillator. The control then provides full manual sweep over the range of frequencies set up on the plug-in.

3.4 TV SYNC SEPARATOR

(Circuit diagram, Fig. 7.3)

A composite television signal can be connected to the external drive input socket, and in the TV mode the signal is switched to the TV sync separator where the frame synchronizing pulses are separated and used to produce a negative-going output pulse.

The circuit action is illustrated by the waveforms in Fig. 3.3. C1 and R2 differentiate the input so that VT1 starts to conduct when the negative-going frame pulses appear; R5 and C2 integrate the output of VT1 so that VT2 conducts when the frame pulses have built up; and C3 and R8 differentiate the output of VT2 for application to the amplifier VT3. VT3 produces 25 V negative-going output pulses of 80 μs duration at TV frame frequency.

3.5 PHASE SHIFT

(Circuit diagram, Fig. 7.3)

The phase shift circuit forms part of the sync trigger sub-unit, and enables the sweep to be shifted by up to 270° with respect to the trailing edge of the incoming mains lock or TV signal. In this way, any part of the waveform being examined can be swept by the high or low frequency ends of the sweep.

The input to VT1 is either a -24 V pulse waveform from the TV sync separator, or a 24 V p-p sine wave from the mains transformer, according to the position of the sweep function switch (TV or mains lock). The signal is inverted and shaped by VT1, passed through a buffer stage VT2, and then differentiated by C2 and R7 (see waveforms Fig. 3.4). The circuit comprising VT3, 4, 5 and 6 introduces a 2:1 delay by producing a square wave having a 2:1 mark:space ratio for every input pulse. VT3 and VT4 form a monostable pair, with VT4 normally biased on until an input pulse via MR2 causes a change of state. VT6 has a reference voltage applied to its base, and supplies a constant current to the charging circuit via C3 and R14. The precise 2:1 delay is introduced when the mean voltage on the base of VT5 balances that on the base of VT6, the voltage on the base of VT5 being derived from the square wave at the collector of VT4. The delayed output is taken from the collector of VT3, and is maintained at the constant 2:1 mark:space ratio over the frequency range 30 to 600 Hz. Since the oscillator operates from 40 to 70 Hz (according to the position of the variable rate control) in mains lock and TV modes, a 400 Hz mains input would trigger the oscillator once for every 10 pulses with a 40 Hz setting, or every 6 pulses with a 70 Hz setting.

The 2:1 square wave is differentiated by C5 and R18 and applied to the ramp generator circuit comprising VT7, 8, 9 and 10. When VT7 conducts during the short period of an incoming positive pulse, C6 is discharged, and then charges up with the constant current supply from VT8 during the interval between positive input pulses. The voltage on the base of VT8 is stabilized by the circuit VT10, R23, R24, C7 and MR5, so that the ramp generated is held at constant amplitude regardless of frequency.

The ramp output is taken from the emitter of VT9 via a preset level control and applied to the phase shift circuit of VT11 and VT12. The output of VT12 is an approximate square wave having a width determined by the setting of the front panel phase shift control; the width can be varied from nearly the full width of the ramp to the last 15% of the ramp. In angular terms, if the ramp represents 360°, the phase shift output pulse can be set to start anywhere between approximately 45° and 315°, giving 270° of phase shift. The start point is determined by the voltage applied to the base of VT12, which accepts the ramp waveform via VT11, and the output pulse is then inverted and shaped by VT13 before being passed to the binary circuit. The circuit action is illustrated by the waveforms in Fig. 3.5, which shows their relationship to the control oscillator output waveform.

3.6 BINARY

(Circuit diagram, Fig. 7.2)

The binary circuit forms part of the sync trigger sub-unit, and receives an input from the phase shift circuit (mains lock and TV) or from the one shot spring-loaded switch. Selection of either function is made by the front panel sweep mode normal - one shot switch. For one shot operation a trigger pulse is produced when the one shot switch is released.

The function of the binary circuit is to produce a clamp output to synchronize the sweep oscillator with the mains lock, TV or one shot signals, and a blanking hold output to inhibit the blanking generator during the flyback and clamping period.

The normal state of the binary is with VT15 biased off by MR12 and R41, so that VT14 is conducting and VT16 - VT17 holds the clamp output at the normal starting level of the oscillator sweep. When a negative-going spike is applied from the differentiating circuit C9 and R34, VT14 is cut off and VT15 starts to conduct; this releases the clamp and the oscillator sweep can commence to rise (see waveforms Fig. 3.6). At the same instant the blanking hold output is inhibited and the blanking generator produces a square pulse lasting for the duration of the sweep. On completion of the charging cycle, when the sweep oscillator changes state, the blanking pulse terminates and a positive-going reset pulse is received from the control oscillator. At the end of the flyback period this reset pulse terminates and resets the binary to its normal state. The phasing of the binary waveforms with respect to the control oscillator output is illustrated in Fig. 3.7.

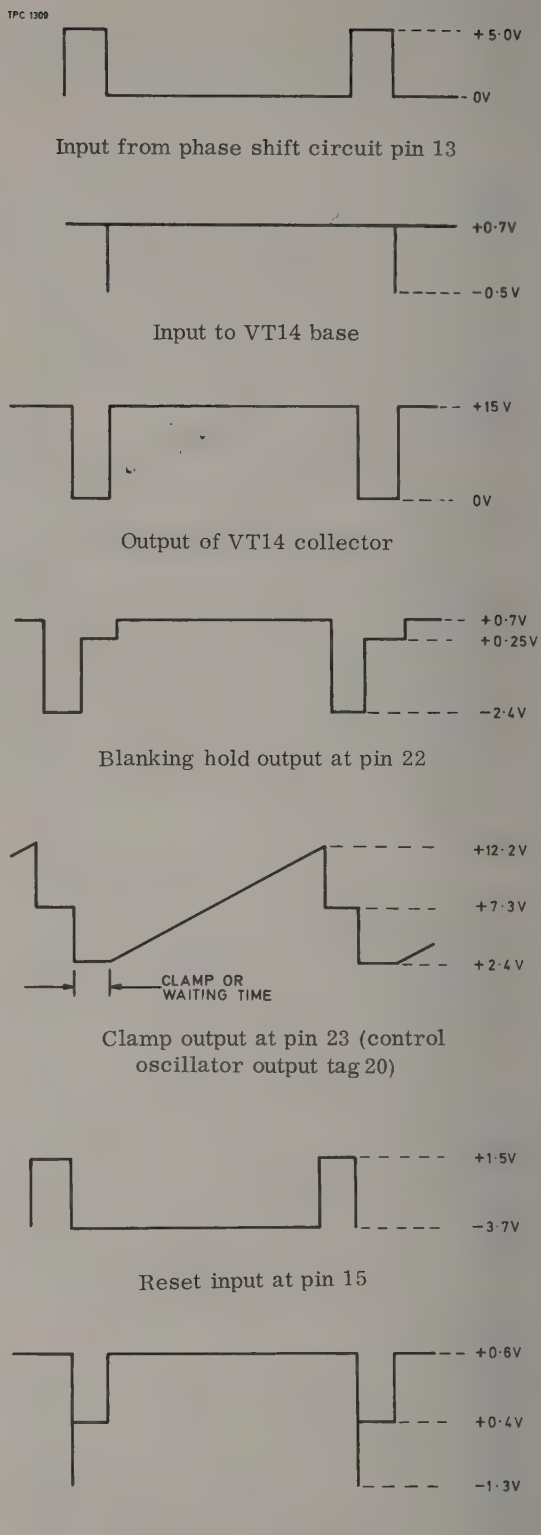


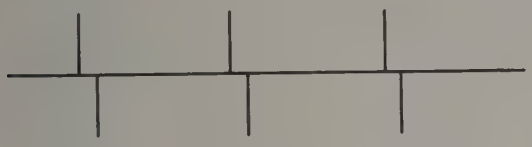
Fig. 3.6 Operation of binary circuit in mains lock or TV mode (ratio 10:1)

3.7 BLANKING GENERATOR

(Circuit diagram, Fig. 7.2)

The blanking generator forms part of the external drive sub-unit, and produces a 24 V positive-going square pulse during the period of each forward sweep, for switching the oscillators and a.l.c. circuit in the sweep unit. The mark to space ratio of the blanking waveform will be 1:1 or 10:1 according to the position of the ratio switch. The blanking signal is also brought out to a front panel socket for use with associated equipment.

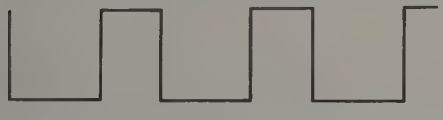
Binary input (phase shift fully counter-clockwise)



Differentiated input to binary VT14

Control oscillator output tag 20

Blanking hold from binary VT14



Blanking output from blanking generator pin 1

Reset input to binary VT15

Blanking drive from control oscillator pin 11

X-drive output 1:1 (forward)

Fig. 3.7 Binary waveforms related to control oscillator output (ratio 1:1)

Input from control oscillator at pin 5

Blanking hold input from binary at pin 6

Blanking hold output to plug-in at pin 1

Fig. 3.8 Operation of blanking generator (ratio 10:1)

VT1 receives a square wave input from VT1 in the control oscillator, which is mixed on VT1 base with the blanking hold signal from the binary circuit (see waveforms Fig. 3.8). The three outputs from the collector of the amplifier VT2 have limiting resistors to protect VT2 from overload.

3.8 EXTERNAL DRIVE AMPLIFIER

(Circuit diagram, Fig. 7.3)

With the sweep function switch set to external, the sweep can be driven from an external source connected to the front panel external drive socket.

The external drive is connected to the base of VT3 via a front panel set level control. VT3 and VT5 form part of a differential amplifier current fed by VT4. VT6 and VT7 are emitter follower output stages which pass the drive to both inputs of the differential amplifier in the control oscillator sub-unit via contacts of the function switch in the external position. The amplifier input and output waveforms are shown in Fig. 3.9.

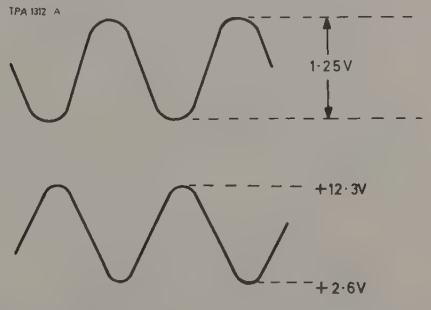


Fig. 3.9 Operation of external drive amplifier (ratio 10:1)

3.9 X-DRIVE AMPLIFIER

(Circuit diagram, Fig. 7.2)

The X-drive amplifier receives a sweep input (1:1 or 10:1) from the differential amplifier, and converts this from a current drive to a voltage drive for use with an oscilloscope or recorder. The output is taken to a front panel socket via a forward-reverse changeover switch and a set level control.

The current drive is applied to the base of VT1, which gives a collector output of 15 V peak (see waveforms Fig. 3.10). Negative feedback from the collector to the base via R1, and emitter feedback via R4, establish constant gain conditions. The signal is fed to VT2 base and emitter (via R7 and R4-R5 respectively) to give overall stability. RV1 and RV2 are preset controls to set the level of VT1 and VT2 collectors with respect to earth potential.

Input from differentiated amplifier at pin 1

Output from pin 8 (reverse)

Output from pin 9 (forward)

Fig. 3.10 Operation of X-drive amplifier (ratio 10: 1)

3.10 MARKER ADDER

(Circuit diagram, Fig. 7.3)

The marker adder circuit enables the markers generated in the plug-in to be superimposed on the detected output from the equipment under test.

A high degree of isolation between the two incoming signals is provided by the 1 MΩ input impedance for the detected signal input using a field effect transistor VT2, which also gives good r.f. smoothing. The two signals are mixed on the collector of VT3, and a low impedance output is taken from the emitter of VT1 to the front panel combined output socket.

3.11 POWER SUPPLIES

(Circuit diagram, Fig. 7.4)

A single mains transformer serves the +24 V, -24 V and +110 V stabilized d.c. power supplies (see block diagram Fig. 3.11). The transformer has five secondaries, as follows:

Secondary 1: 30 V at 500 mA, +24 V supply
Secondary 2: 30 V at 500 mA, -24 V supply
Secondary 3: 129 V at 75 mA, +110 V supply
Secondary 4: 11.8 V at 15 mA, 16 V auxiliary supply
Secondary 5: 9 V at no load, mains lock signal

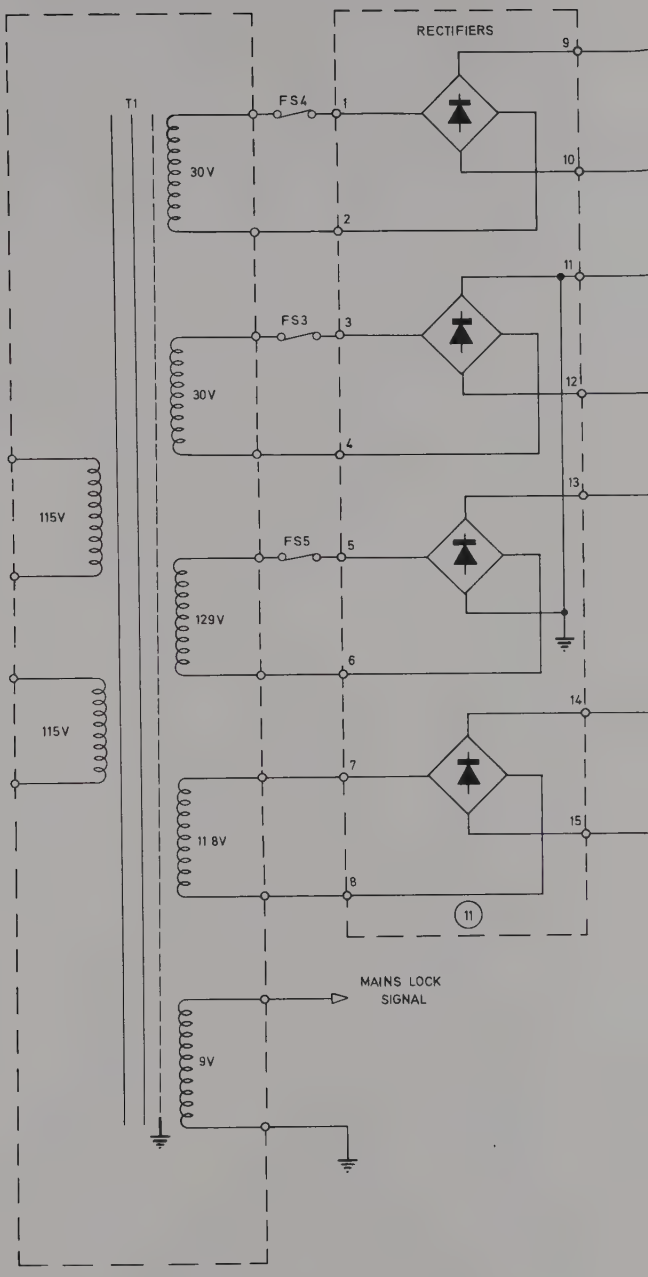
The first four supplies are rectified by silicon diode bridge rectifier circuits with capacitive filters before being applied to the three d.c. stabilizers. The +24 V stabilized supply is used as the reference for the -24 V and +110 V stabilizers.

For the +24 V stabilizer, a sample of the +24 V output is taken from the chain MR1, MR2 and R7 and applied to the differential emitter-coupled amplifier VT4 and VT5, any changes from the correct level being amplified and passed to a second differential amplifier VT2 and VT3. A change at the collector of VT3 then alters the base potential of the series regulator VT6 so as to restore the output to its correct level. The required output level is established by the setting of the preset control RV1. VT1 gives overload

protection by starting to conduct when the voltage developed across R1 rises beyond a safe limit, thus disabling the control circuit and preventing damage to VT6.

The -24 V stabilizing circuit is identical, except that the reference potential for the overload protection circuit and differential amplifier is obtained from a separate winding on the mains transformer, through an associated rectifier circuit.

The 110 V stabilizer comprises a high gain d. c. amplifier which forms a feedback loop with an r. f. oscillator, the rectified r. f. output being used to control a series regulator transistor. Reference for the stabilizer is provided by the +24 V stabilized line. Basically a Hartley circuit, the oscillator output is taken from a transformer secondary, rectified and smoothed and applied between the emitter and base of the series regulator transistor. An increase in load current causes an initial drop in output voltage due to the secondary source impedance. This drop is detected by the balanced pair VT2 and VT3 and amplifier VT1 which produces an increased supply voltage to the oscillator, thereby raising its output level. This in turn is seen as an increase in its secondary voltage and hence its rectified output.


RECTIFIERS
T1
FS4
FS3
FS5
30 V
30 V
115V
115V
129V
11 8V
9V
MAINS LOCK
SIGNAL
1
2
3
4
5
6
7
8
9
10
11
12
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14
15
11

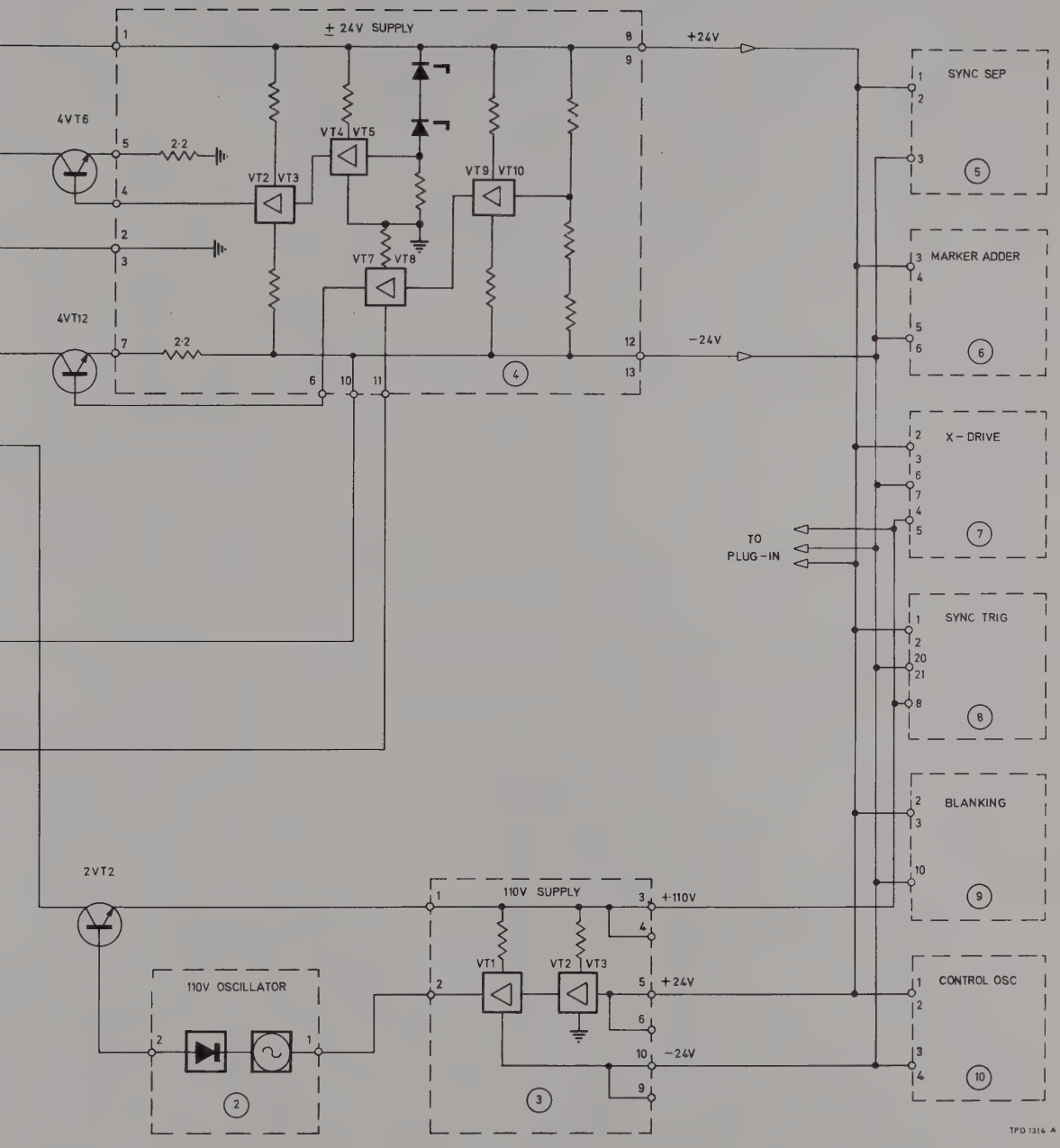


Fig. 3.11 Power supplies block diagram

Chapter 4

Maintenance

4.1 INTRODUCTION

This chapter contains information for keeping the equipment in good working order and for checking its performance.

4.2 TEST EQUIPMENT REQUIRED

This section provides a list of the test equipment that will be required to carry out the performance checks detailed in this chapter.

a) Dummy load, see Fig. 4.1.

b) Oscilloscope, such as M.I. TF 2201 or M.I. TF 2210 or Tektronix 547 with type W plug-in.

c) RC oscillator, such as M.I. TF 1101.

d) Resistor, 50 kΩ $\frac{1}{4}$ W.

e) Resistor, 1 kΩ $\frac{1}{4}$ W.

f) Mains transformer, variable.

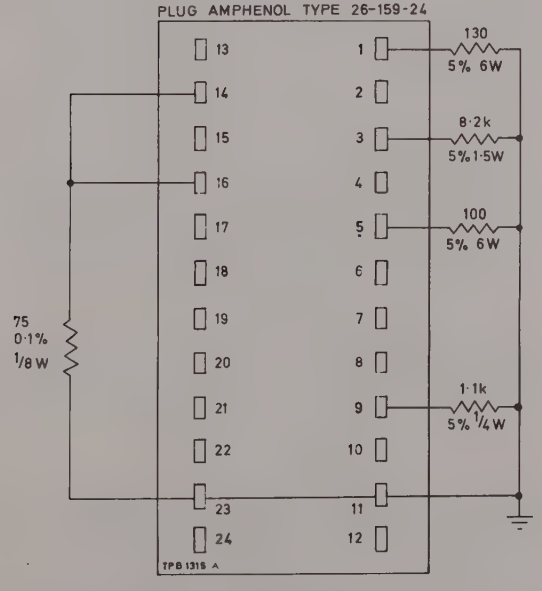


Fig. 4.1 Dummy load

4.3 INITIAL CONDITIONS

Before commencing the performance checks, construct the dummy load according to Fig. 4.1. Remove the plug-in oscillator from the main unit, and connect the dummy load to the 24-way socket on the main unit. The performance checks should not be carried out with the plug-in oscillator in position, because faulty performance in the plug-in can be reflected back into the main unit.

Set the front panel controls on the main unit to the following positions:

SUPPLY SWITCH OFF.

SWEEP FUNCTION switch at 10 - 100 Hz.

VARIABLE RATE fully clockwise.

PHASE SHIFT control fully counter-clockwise.

RATIO switch at 1:1.

SWEEP MODE switch at NORMAL.

BLANKING ON.

A.L.C. switch at INTERNAL.

MARKER switch OFF.

X-DRIVE LEVEL control fully counter-clockwise.

EXTERNAL DRIVE SET LEVEL control fully counter-clockwise.

X-DRIVE switch at FORWARD.

4.4 PERFORMANCE CHECKS

4.4.1 Internal sweep

Test equipment: a and b

(1) Connect the vertical input of the oscilloscope to the X-DRIVE OUTPUT socket, and switch the supply on.

(2) Set the X-DRIVE switch to suit the oscilloscope time base, and adjust the X-DRIVE LEVEL control so that the displayed waveform occupies the fully vertical displacement of the graticule.

(3) Set the SWEEP FUNCTION switch to 0.01 - 0.1 Hz, and the VARIABLE RATE control fully counter-clockwise. Check that the time taken for the spot to complete one cycle up and down the graticule is greater than 100 seconds.

(4) Set the VARIABLE RATE control fully clockwise, and check that the time taken for the spot to complete one cycle is less than 10 seconds.

(5) Set the SWEEP FUNCTION switch to 0.1 - 0.1 Hz and the VARIABLE RATE control fully counter-clockwise. Check that the time taken for the spot to complete one cycle is greater than 10 seconds.

(6) Set the VARIABLE RATE control fully clockwise and the oscilloscope time base to 500 ms/cm. Check that one cycle of the displayed waveform occurs in less than 1 second.

(7) Set the SWEEP FUNCTION switch to 1 - 10 Hz and the VARIABLE RATE control fully counter-clockwise. Check that the sweep time is greater than 1 second.

(8) Set the VARIABLE RATE control fully clockwise and check that the sweep time is less than 100 ms.

(9) Set the SWEEP FUNCTION switch to 10 - 100 Hz and the VARIABLE RATE control fully counter-clockwise. Check that the sweep time is more than 100 ms.

(10) Set the VARIABLE RATE control fully clockwise and check that the sweep time is less than 10 ms.

4.4.2 Mains lock and TV

Test equipment: a and b

(1) Set the oscilloscope to mains trigger with time base set at 1 ms/cm. Set the SWEEP FUNCTION switch to MAINS LOCK, and adjust the VARIABLE RATE control to give a waiting time (see Fig. 4.2) of 500 μs.

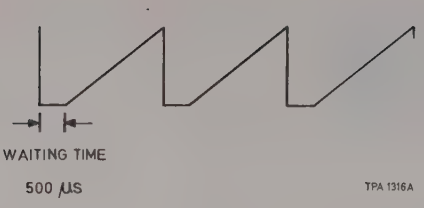


Fig. 4.2 Mains lock waiting time

(2) Set the oscilloscope time base to 5 ms/cm, and adjust the PHASE SHIFT control from fully clockwise to fully counter-clockwise. Check that this gives at least 270 ^{o} of phase shift.

(3) To check the TV input, connect a composite TV signal to the EXTERNAL DRIVE socket, set the SWEEP FUNCTION switch to TV and repeat checks (1) and (2) above.

4.4.3 External and CW

Test equipment: a, b and c

(1) Set the oscilloscope to internal trigger, connect the a.f. signal generator to the EXTERNAL DRIVE socket, set the SWEEP FUNCTION switch to EXTERNAL, and set the r-c oscillator (maximum output 4.5 V p-p) to 20 Hz.

(2) Check that the waveform displayed on the oscilloscope is an undistorted replica of the input sine wave, capable of being adjusted to 30 V p-p by the EXTERNAL DRIVE SET LEVEL control. Repeat this check with the r-c oscillator set at 1 kHz, 5 kHz, 10 kHz and 20 kHz. Disconnect the oscillator.

(3) The c.w. mode only operates in conjunction with a sweep unit, and the check for it is covered in the handbook for the sweep unit.

4.4.4 Manual

Test equipment: a and b

(1) Set the oscilloscope time base to 5 ms/cm, and the SWEEP FUNCTION switch to MANUAL.

(2) A straight line trace will be displayed; check that the VARIABLE RATE control moves this line up and down the full displacement of the graticule.

4.4.5 One shot operation

Test equipment: a and b

(1) Set the SWEEP MODE switch to ONE SHOT, the SWEEP FUNCTION switch to 0.01 - 0.1 Hz, and the VARIABLE RATE control fully counter-clockwise.

(2) Wait for the trace to settle, then press the ONE SHOT switch and release it. Check that the trace rises and returns for one cycle only.

(3) Repeat with the VARIABLE RATE control fully clockwise.

(4) Repeat for the other three internal ranges of the SWEEP FUNCTION switch, with the VARIABLE RATE control fully counter-clockwise and fully clockwise. After the checks, return the SWEEP MODE switch to the NORMAL position.

4.4.6 Blanking and sweep ratio

Test equipment: a and b

(1) Transfer the oscilloscope to the BLANKING OUTPUT socket with the time base set to 2 ms/cm, set the SWEEP FUNCTION switch to 10 - 100 Hz, set the RATIO switch to 1:1, and adjust the VARIABLE RATE control fully clockwise.

(2) Check that the amplitude of the displayed waveform is greater than 22 V.

(3) Set the RATIO switch to 1:1 or 10:1 according to the requirements of the oscilloscope in use, adjust the oscilloscope to display one pulse of the waveform and check the pulse rise and decay time. The rise time should be less than 4 μs over the 10-90% portion of the waveform, and the decay time less than 20 μs over this portion.

(4) Adjust the oscilloscope to check the sweep ratios. On 1:1 the ratio should be between 0.9:1 and 1.1:1, and on 10:1 it should be between 9:1 and 13:1.

4.4.7 X-drive

Test equipment: a, b, d and e

(1) Connect the oscilloscope vertical input to the X-DRIVE OUTPUT socket, via a T-junction adaptor. Set the RATIO switch at 1:1, the SWEEP FUNCTION switch at 10 - 100 Hz, and the VARIABLE RATE and X-DRIVE LEVEL controls fully clockwise.

(2) Check that the displayed waveform is symmetrical about earth, and has an amplitude of at least 30 V with a 50 kΩ load resistor across the T-junction, and at least 2 V with a 1 kΩ load resistor across the T-junction.

4.4.8 Amplitude of sweep drive

Test equipment: a and b

(1) Connect the oscilloscope across the 75 Ω resistor on the dummy load (pins 23 and 14-16).

(2) Check that the p-p amplitude of the displayed waveform is 308 mV. This is an approximate test, because the accuracy of the sweep waveform level is outside the limits of an oscilloscope. Testing to full specification entails taking the instrument out of its case, and if this is necessary refer to the procedure given in Chap. 5.

4.4.9 Power supply stabilizers

Test equipment: a, b and f

(1) Connect the Variac, set to 115 V or 230 V output according to the range in use, between the a.c. supply and the a.c. input socket. Connect the oscilloscope to the X-DRIVE OUTPUT, and display the internal 100 Hz sweep waveform at a level of 30 V.

(2) Vary the a.c. mains input by ±10% on the Variac, and check that there is no perceptible variation in the level of the displayed waveform.

Chapter 5

Repair

5.1 INTRODUCTION

This chapter contains information for adjustment or repair following failure of the instrument to pass any of the performance checks detailed in Chap. 4.

Before attempting any adjustment or repair, read the technical description given in Chap. 3.

CAUTION

This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness, are susceptible to damage through overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as reversed potentials, prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an unearthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of any associated transistors.

The performance limits quoted in this chapter are for guidance only and should not be taken as guaranteed performance specifications unless they are also quoted in the Data Summary section.

5.2 SCREW FASTENERS

Screw threads used on this equipment are of the following sizes: 8 BA, 6 BA, 4 BA and 2 BA.

Cruciform headed screws are of the Pozidriv type; to avoid damaging them a Pozidriv screwdriver should be used.

5.3 REMOVAL OF COVER

To remove the instrument from its case, undo the four 2 BA screws at the rear and slide the instrument forward. Alternatively, turn the instrument with its front panel resting on a soft surface and slide the case off.

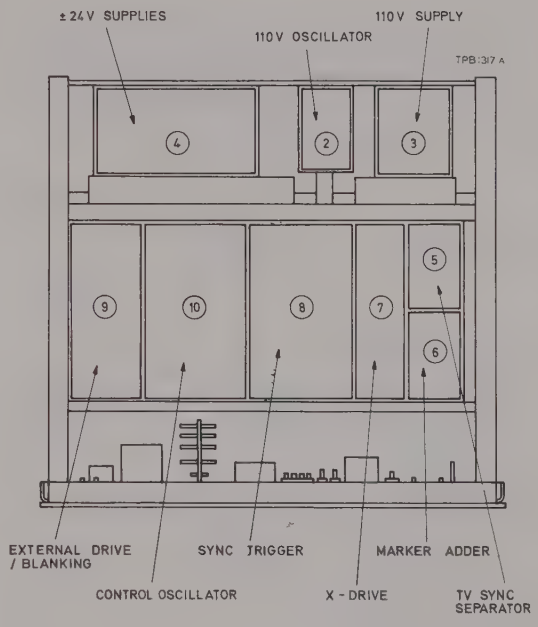


Fig. 5.1 Location of printed circuit boards, underside of chassis

5.4 ACCESS TO PRINTED CIRCUIT BOARDS

All components of the main unit are accessible from the underside of the chassis, except the power supply transformer and rectifier circuits which are accessible from the top, behind the plug-in unit. The eight printed circuit boards accessible from the underside are arranged as shown in Fig. 5.1; each board is mounted in an open tray, except the 110 V oscillator board which is fully enclosed with a clip-on cover. To remove this cover, lever it off by inserting the blade of a small screwdriver under the lip provided for this purpose.

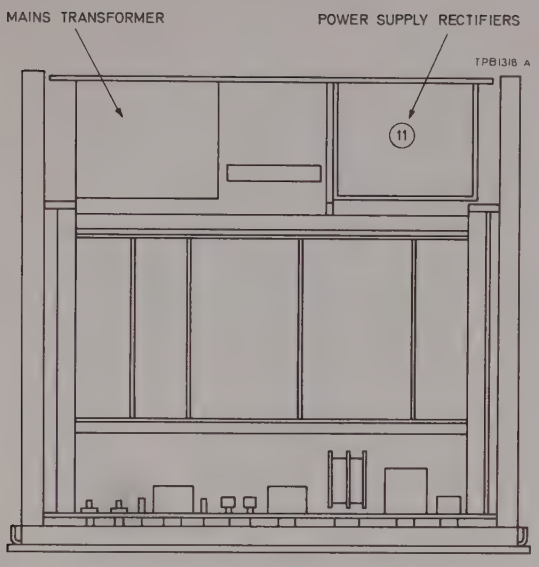


Fig. 5.2 Location of printed circuit boards, top of chassis

The boards on top of the chassis are shown in Fig. 5.2.

Each printed circuit board can be raised up out of its tray for inspection or repair by removing the four 6 BA screws holding it in position and if necessary it can then be completely removed by disconnecting the wired terminals which are pressed on to spigots on the board. It is possible to get a test probe on to these terminals without removing the wires, a short section of the spigot being left exposed between the board and the insulated sleeving round the terminal.

CAUTION

When removing, inserting or working on printed circuit boards, take care not to bend them or to damage the printed circuit tracks on the underside of the boards. Bending can cause hair-line breaks in a track, and such breaks are very difficult to locate.

If it is found necessary to remove a printed circuit board for return to the manufacturer, it should be removed complete with its tray. Each tray is held in position by four 4 BA screws, two on a flange at the front and two at the rear.

5.5 ACCESS TO PRESET CONTROLS

All preset controls are mounted on the printed circuit boards accessible from the underside of the chassis. For the location of these controls, refer to Fig. 5.3.

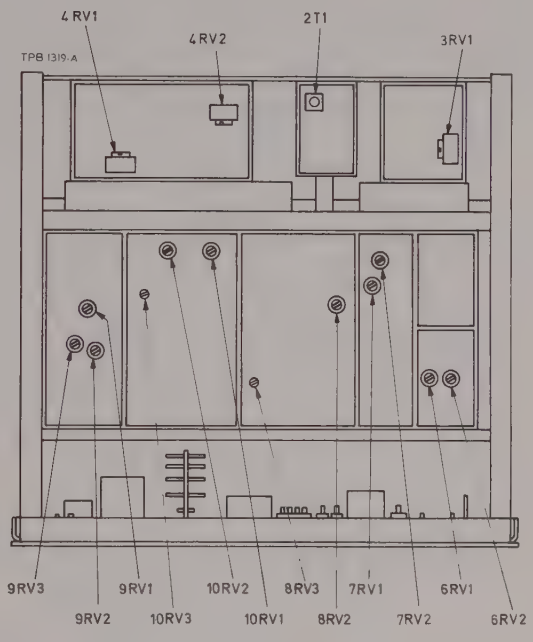


Fig. 5.3 Location of preset controls

5.6 COMPONENT LOCATION

Component location diagrams are shown in Figs. 5.4 to 5.13, and these diagrams also show the location of the board terminals. For front and rear panel components, refer to Figs. 2.2 and 2.3 respectively.

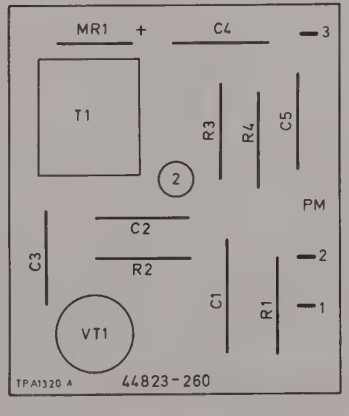


Fig. 5.4 Component location, Board 2, 110 V oscillator

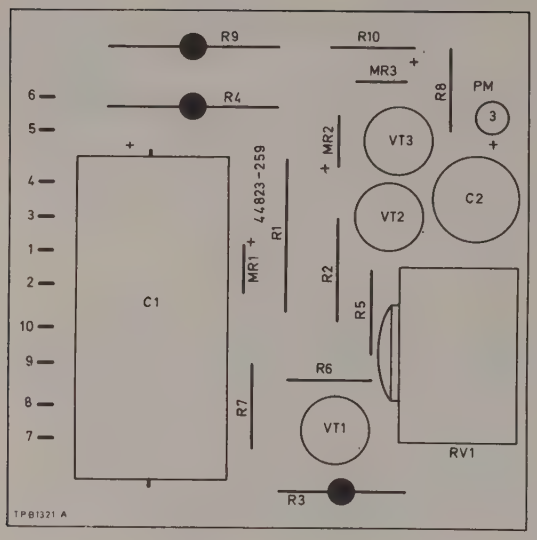


Fig. 5.5 Component location, Board 3, 110 V supply

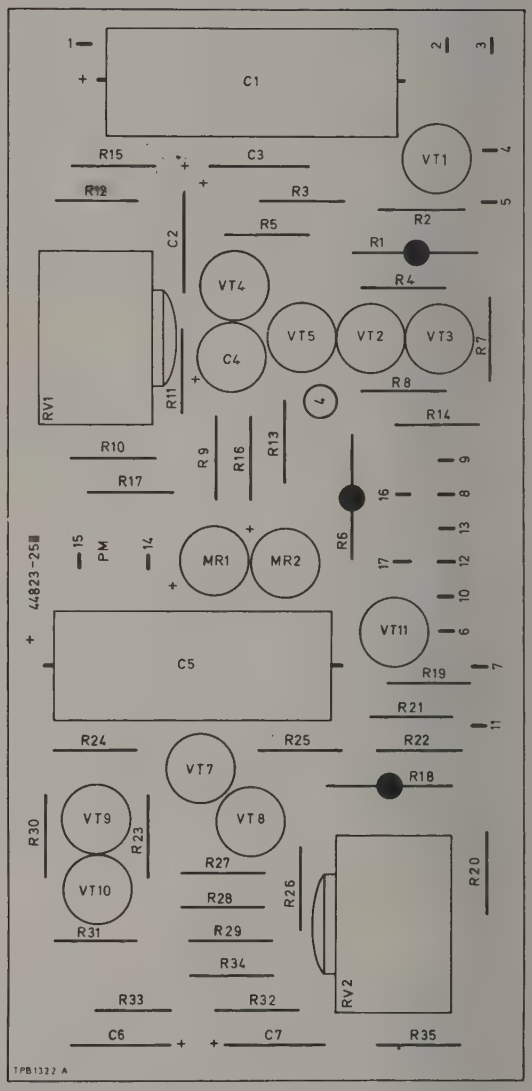


Fig. 5.6 Component location, Board 4, 24 V supply

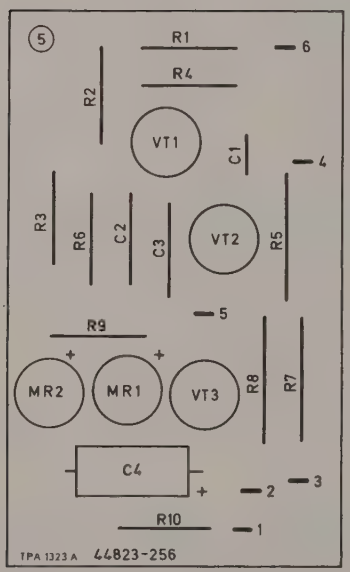


Fig. 5.7 Component location, Board 5, TV sync separator

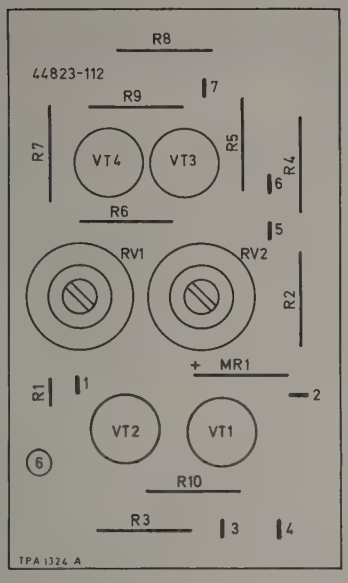


Fig. 5.8 Component location, Board 6, Marker adder

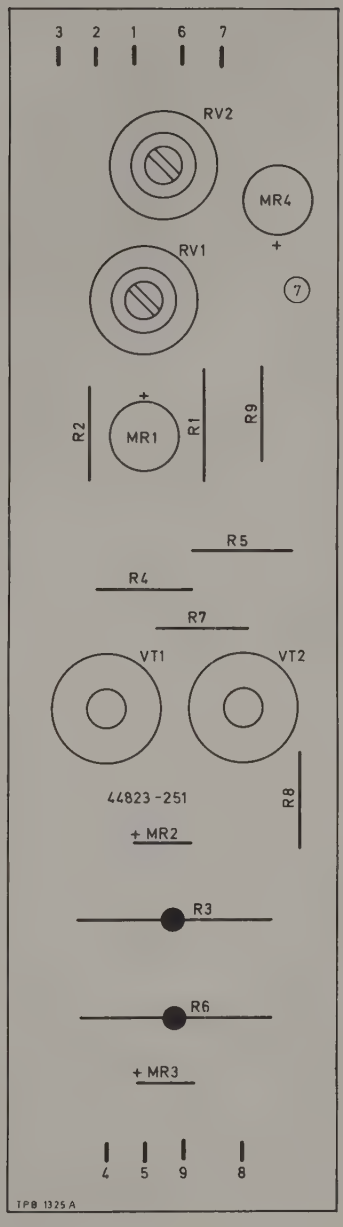


Fig. 5.9 Component location, Board 7, X-drive amplifier

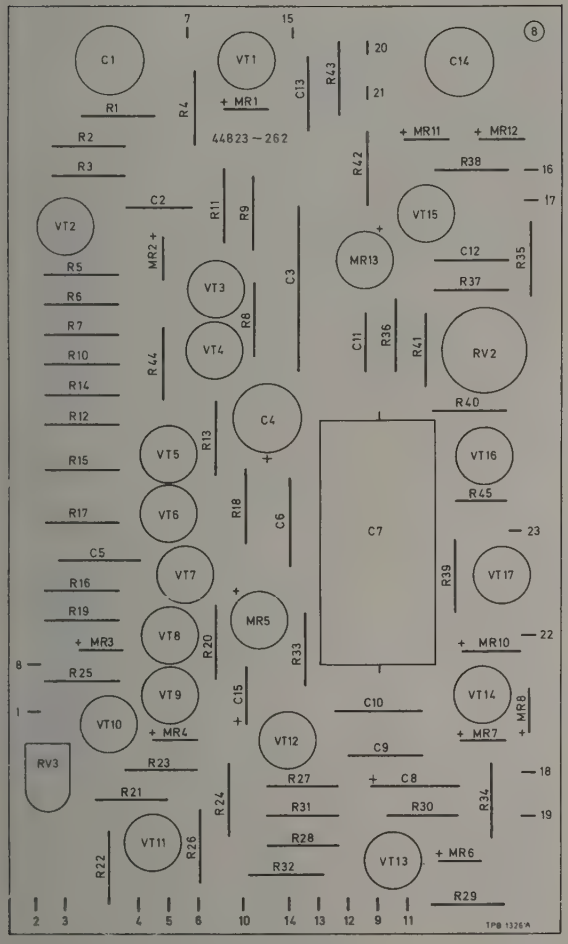


Fig. 5.10 Component location, Board 8, Sync trigger and binary

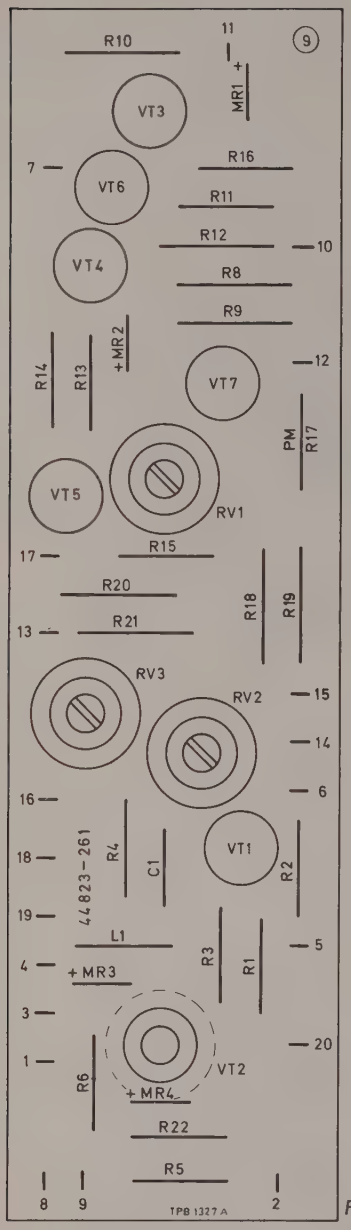


Fig. 5.11 Component location, Board 9, Blanking and ext. drive

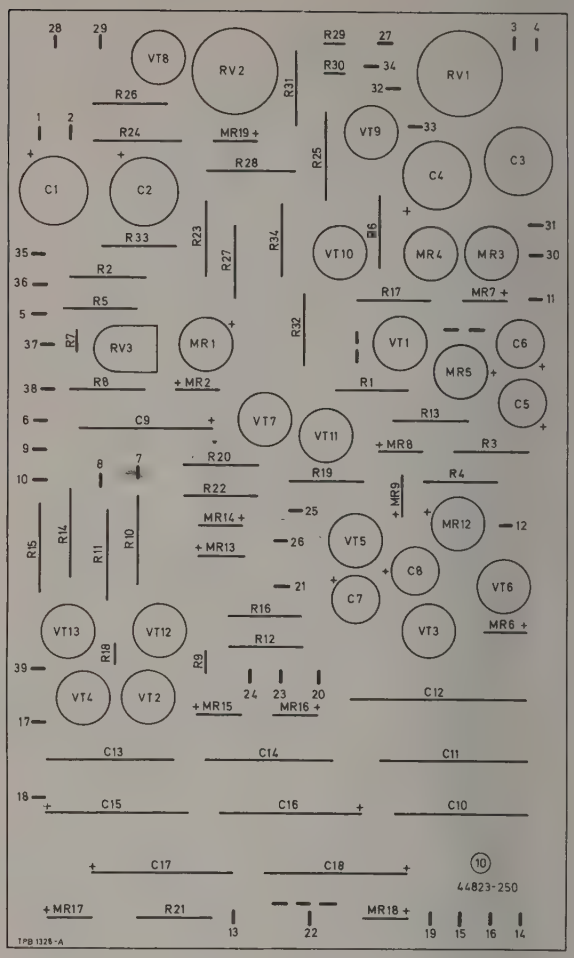


Fig. 5.12 Component location, Board 10, Control oscillator

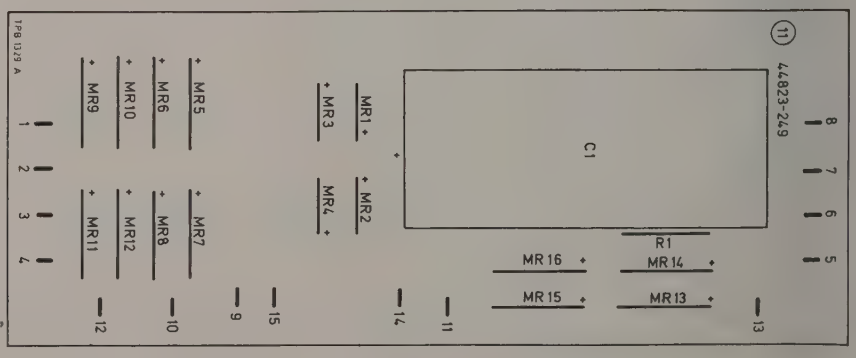


Fig. 5.13 Component location, Board 11, Power supply rectifiers

5.7 ADJUSTMENT AND CALIBRATION

This section provides a list of the test equipment that will be required to carry out the adjustment and calibration procedures detailed in this chapter. Do not attempt to calibrate the instrument using test equipment having an accuracy less than that of the items recommended. If repairs are necessary and adequate test equipment is not available, the instrument should be returned to the manufacturer, where a repair and calibration service is provided.

a) Dummy load, see Fig. 4.1

b) Oscilloscope, Tektronix type 547.

c) Oscilloscope plug-in, Tektronix type W.

d) Oscilloscope plug-in, Tektronix type 1A1.

e) Oscilloscope probe (two), Tektronix P 6023.

f) R C oscillator, M.I. type TF 1370A.

g) Digital voltmeter, Digital measurements type DM 2005.

h) Transformer, variable, Variac.

i) Multimeter, 20 000 Ω/V, such as Avometer, model 8.

j) Differential voltmeter, M.I. type TF 2606.

k) Counter frequency meter, such as M.I. TF 1417 series.

l) Blanking and sync mixer, M.I. type TF 2908.

m) V.L.F. oscillator, 0.01 to 10 kHz.

n) Sync pulse generator, BD 289.

p) Video sweep unit, M.I. type TM 9692.

q) Video detector (supplied with p), M.I. type TM 9703.

r) 1 kΩ pad, see Fig. 5.14.

s) 50 kΩ resistor, 1%, 3/4 W.

t) 1 kΩ resistor, 1%, 3/4 W.

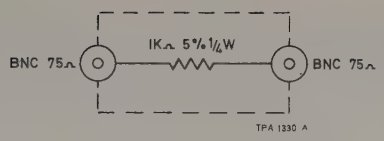


Fig. 5.14 1 kΩ pad

5.7.1 Initial conditions

For adjustment and calibration, the instrument should be removed from its case (see Sect. 5.3) and operated on its side so that the preset controls are accessible. Remove the plug-in unit and fit the dummy load (Fig. 4.1) to the 24-pin socket on the main unit. Do not operate the instrument with the cover removed from the 110 V oscillator board.

WARNING When the instrument is operated in this condition, dangerous voltages are accessible near the mains transformer. Take all necessary precautions to avoid contact with these voltages.

Set the front panel controls to the following positions:

SUPPLY switch OFF

MARKER switch OFF

A.L.C. switch INT

X-DRIVE switch FORWARD

X-DRIVE OUTPUT LEVEL fully clockwise

RATIO switch 1:1

BLANKING switch ON

SWEEP MODE switch NORMAL

PHASE SHIFT control fully counter-clockwise

SWEEP FUNCTION switch 10 - 100 Hz

VARIABLE RATE control fully clockwise

EXTERNAL DRIVE SET LEVEL control fully counter-clockwise

5.7.2 Power supply regulation

Test equipment: a, b, c, e, h, i and j

(1) Connect the Variac, set to 115 V or 230 V output according to the range in use, between the mains supply and the mains input socket, with the multimeter (250 V a.c. range) connected across

the Variac output. Connect the Y input of the oscilloscope to pin 1 on the dummy load. Connect the differential voltmeter TF 2606 to pin 1 on the dummy load (positive) and earth and set it to discriminate 100 mV at 24 V. Switch the supply on.

(2) Check that the voltmeter indicates +24 V ±50 mV; if necessary adjust RV1 on the 24 V supplies board (board 4).

(3) Apply a short circuit across the +24 V supply (dummy load pin 1 to earth) for 1 second, and check that the voltage recovers to within 5 mV of its original value when the short circuit is removed.

(4) Set up the differential voltmeter for a null balance, and use the Variac to change the mains supply voltage. Check that the +24 V supply does not vary by more than ±10 mV for a ±15% change in mains voltage.

(5) Display the +24 V supply on the oscilloscope, and check that the ripple does not exceed 1 mV p-p for a ±10% change in mains voltage. Reset the Variac to nominal mains voltage.

(6) Transfer the oscilloscope and differential voltmeter from pin 1 to pin 5 (negative) on the dummy load.

(7) Repeat (2) to (5) for the -24 V supply, adjusting RV2 on board 4 if necessary.

(8) Set the differential voltmeter to discriminate 100 mV at +110 V. Transfer the oscilloscope and differential voltmeter from pin 5 to pin 3 (positive) on the dummy load.

(9) Check that the voltmeter indicates +110 V ±100 mV; if necessary adjust RV1 on the 110 V supply board (board 3). If this voltage cannot be obtained, or can only be obtained with RV1 at the limit of its travel in one direction, check the output of the 110 V oscillator. To do this, remove the cover from the 110 V oscillator board (see Sect. 5.4) and connect the oscilloscope set to display a 7 MHz waveform to the connection between MR1 and T1. Then adjust the core of the oscillator transformer T1 for maximum output. Replace the cover on the board before resuming the tests.

(10) Apply a short circuit across the +110 V supply (dummy load pin 3 to earth) for 1 second, and check that the voltage recovers to within ±50 mV when the short circuit is removed.

(11) Set up the differential voltmeter for a null balance, and use the Variac to change the mains supply voltage. Check that the +110 V supply does not vary by more than ±20 mV for a ±15% change in mains voltage.

(12) Display the +110 V supply on the oscilloscope, and check that the ripple does not exceed 10 mV p-p for a ±10% change in mains voltage. Disconnect the Variac, multimeter, oscilloscope and differential voltmeter.

5.7.3 Internal sweep

Test equipment: a, b, c, g and k

(1) Connect the oscilloscope X input to the X-drive output socket, and the oscilloscope Y input to pin 21 on the control oscillator board (board 10).

(2) Check that the oscillator is operative on the four internal ranges of the sweep function switch (0.01 to 100 Hz), with the ratio switch set at 1:1 and 10:1.

(3) Set up the oscilloscope for differential operation, as follows: set the display to A-B; connect two probes to the two inputs and link the two earth leads but make no connection to earth; set the oscilloscope to AUTO, time base to 20 ms/cm and input sensitivity to 200 mV/cm.

(4) Set the SWEEP FUNCTION switch to 0.01 - 0.1 Hz and the RATIO switch to 10:1.

(5) Connect both the A and B probes to the junction of C17 and C18 on board 10, and adjust the trace to the top line of the graticule. Connect probe A to the other end of C17, switch the supply to the main unit off and discharge C17 and C18. Switch the supply to the main unit on and check that the first negative excursion of the trace does not exceed 1 V (5 cm). Repeat this test with probe A connected to the other end of C18, and repeat both tests for a ratio setting of 1:1.

(6) Repeat (5) with the sweep function switch set to 0.1 - 1 Hz, measuring across capacitors C13 and C14.

(7) Set the SWEEP FUNCTION switch to 10 - 100 Hz and the RATIO switch to 1:1. Reset the oscilloscope for normal use.

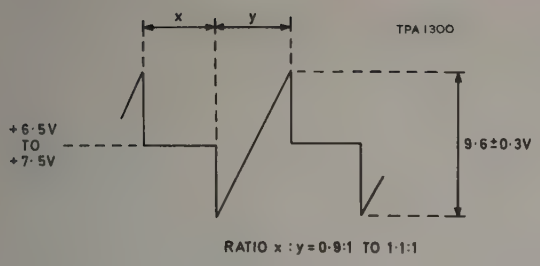


Fig. 5.15 Control oscillator waveform, 1:1 ratio

(8) Connect the oscilloscope to pin 21 on board 10 and check that the level and ratio of the waveform is as shown in Fig. 5.15.

(9) Set the RATIO switch to 10:1 and check that the level and ratio of the waveform is as shown in Fig. 5.16.

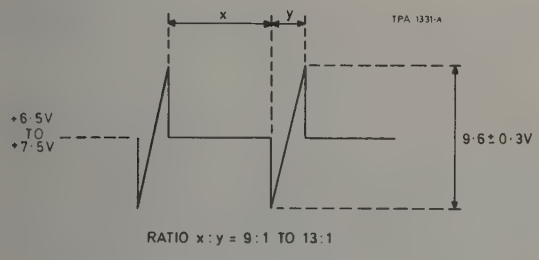


Fig. 5.16 Control oscillator waveform, 10:1 ratio

(10) Set the SWEEP FUNCTION switch to TV and check that the oscillator is inhibited, and that the d.c. level of the trace is between +6.5 V and +7.5 V. Repeat with the RATIO switch at 1:1.

(11) Set the SWEEP FUNCTION switch to EXTERNAL, CW and MANUAL in turn, adjusting the VARIABLE RATE control over its full range in each case. Check that the oscillator remains inactive during each test. Disconnect the oscilloscope.

(12) Connect the start B socket on the counter frequency meter to the BLANKING OUTPUT socket. Set the counter to period B and the first clockwise ms position. Set the VARIABLE RATE control fully counter-clockwise, and set the SWEEP FUNCTION to one of the internal sweep ranges.

(13) Allow at least three complete cycles of operation on any range before taking measurements. Note the values marked with an asterisk in the following table and, by switching to each range in turn, find the range which gives a rate on the counter nearest to one of these marked values. Then adjust RV3 on board 10 to give +10% on the value quoted. For example, if the 1 - 10 Hz range is nearest at 1.05 second, adjust RV3 so that the counter records 1.1 second.

Sweep function switch	*Variable rate control*	*Sweep time*		*Frequency (Hz)*
		min.	*max.*	
10 - 100 Hz	FCW	7 ms	10 ms	100 min
	FCCW	100 ms *	130 ms	10 max
1 - 10 Hz	FCW	70 ms	100 ms	10 min
	FCCW	1 sec *	1.3 sec	1 max
0.1 - 1 Hz	FCW	0.7 sec	1.0 sec	1 min
	FCCW	10 sec *	13 sec	0.1 max
0.01 - 0.1 Hz	FCW	7 sec	10 sec	0.1 min
	FCCW	100 sec *	130 sec	0.01 max

FCW = fully clockwise FCCW = fully counter-clockwise

(14) Check that the VARIABLE RATE control adjusts the sweep rate within the minimum and maximum limits quoted for each internal range, with the ratio switch set at 1:1 and 10:1. On the lowest range, the time at 100 seconds must not exceed 150 seconds. Disconnect the counter.

(15) Connect input A of the oscilloscope to pin 14 on the dummy load using a 1:1 probe, and set the oscilloscope for comparative voltage checking as follows: set the type W plug-in to A-Vc, input A to ground, input attenuator to 1, mV/cm to 10, Vc range to 1.1 and Vc digits to zero.

(16) Set the SWEEP FUNCTION switch to 10 - 100 Hz, RATIO switch to 1:1 and VARIABLE RATE control fully counter-clockwise.

(17) Adjust the oscilloscope to set the trace to the lowest line of the graticule, then switch input A to d.c.

(18) Set the digits on the oscilloscope plug-in for a Vc of 33.75 mV (i.e. 3 in the middle window and 37.5 on the inner scale). Adjust RV1 (level) and RV2 (amplitude) on board 10 progressively until the negative peak of the displayed waveform is on the lowest line of the graticule. Note that RV1 and RV2 interact.

(19) Set the digits for a Vc of 341.25 mV (i.e. 3 on outer knob, 4 in the middle window and 12.5 on the inner scale). Adjust RV1 and RV2 again until the positive peak of the displayed waveform is on the lowest line of the graticule.

(20) Repeat (18) and (19) until both conditions are satisfied. Disconnect the oscilloscope.

(21) Connect the input of the digital voltmeter to pin 14 on the dummy load, and set the digital voltmeter range to 0.7999, filter C R to 0, resolution to 1 and trip to counter-clockwise. Set the SWEEP FUNCTION switch to 0.01 - 0.1 Hz, RATIO switch to 1:1 and VARIABLE RATE control fully counter-clockwise.

(22) Set the digital voltmeter mode to 'min' and check that it indicates 33.75 mV ±1 mV. Set the mode to 'max' and check that it indicates 341.25 mV ±1 mV. Note that the readings are held until cancelled by the min - max switch.

(23) Set the RATIO switch to 10:1 and repeat (22), the limits for this test being ±2 mV. Disconnect the digital voltmeter.

5.7.4 X-drive, sweep linearity and one shot operation

Test equipment: a, b, c, s and t

(1) Connect the oscilloscope to the X-drive output socket via a T-junction adaptor, and connect the 50 kΩ resistor across the T-junction. Set the SWEEP FUNCTION switch to 10 - 100 Hz, RATIO switch to 10:1 and VARIABLE RATE control fully clockwise.

(2) Check that the amplitude of the displayed waveform is at least 30.5 V p-p, and adjust RV1 on the X-drive board (board 7) for equal positive and negative excursions on either side of earth, ±1 V.

(3) Set the X-DRIVE switch to REVERSE, and repeat (2), adjusting RV2 on board 7 for equal excursions about earth.

(4) Remove the 50 kΩ resistor and fit the 1 kΩ resistor in its place. Check that the amplitude of the displayed waveform is at least 2.1 V p-p, and repeat with the X-DRIVE switch in the FORWARD position. Set the X-DRIVE control fully counter-clockwise and check that the level is less than 0.1 V p-p.

(5) Remove the 1 kΩ resistor and fit the 50 kΩ resistor in its place. Set the X-DRIVE LEVEL control fully clockwise and the RATIO switch to 1:1. Check that the negative-going spike on the X-drive ramp is less than 1.5 V. Note the precise level for a subsequent check in 5.8.5 (12).

(6) Set the RATIO switch to 10:1 and display one cycle of the sweep over the full extent of the graticule. Check the linearity of the ramp over the centre 92%; it should be a straight line within 3% (0.01 - 0.1 Hz) or 2.5% (0.1 - 100 Hz). For accurate measurement of this linearity, a chart recorder should be connected to the X-DRIVE OUTPUT to give a tracing of the sweep waveform.

(7) Set the SWEEP MODE switch to ONE SHOT and operate the ONE SHOT switch. Check that when the switch is released a single sweep is generated. Repeat for the other three internal ranges on the SWEEP FUNCTION switch. On completion, set the SWEEP MODE switch back to NORMAL.

5.7.5 TV sync separator and sync trigger

Test equipment: a, b, d, f, l, n and r

(1) Feed blanking and sync pulses (625 line system) from the synchronizing pulse generator to the blanking and sync inputs of the blanking and sync mixer, also feed a 10 MHz sine wave (75 Ω source and 700 mV amplitude) from the attenuator output of the R C oscillator to the video input of the blanking and sync mixer. Set the blanking and sync mixer to give a 1 V composite signal output (600 mV video, 300 mV sync and 100 mV blanking) and connect this output to the EXTERNAL DRIVE INPUT socket on the sweep generator. Set the SWEEP FUNCTION switch to TV and the RATIO switch to 1:1.

(2) Connect the oscilloscope (fitted with the type 1A1 plug-in) to pin 7 on the sync trigger board (board 8) and check that the displayed waveform is a pulse of 50 Hz ±5 Hz frequency, width less than 150 μs, amplitude more than 20 V peak, and rise time less than 10 μs. Remove the inputs to the blanking and sync mixer.

(3) Feed negative field blanking pulses at 300 mV from the synchronizing pulse generator to the sync input of the blanking and sync mixer. Repeat (2). Disconnect the synchronizing pulse generator and the blanking and sync mixer.

(4) Connect the R C oscillator lower output socket to the external drive socket via the 1 kΩ pad, and set the oscillator output to 50 Hz sine wave. Connect the oscilloscope to the sweep generator side of the 1 kΩ pad and adjust the oscillator level to give 4.8 V p-p. Repeat para (2).

(5) Change the R C oscillator frequency to 400 Hz sine wave at the same level, and connect the oscilloscope time base and channel 1 input to pin 7 on board 8. Set the oscilloscope to chop, and connect channel 2 input to pin 12 on board 8. Check that the frequency displayed is 400 Hz ±20 Hz.

(6) Set the PHASE SHIFT control fully clockwise and adjust RV3 on board 8 so that the width of the pulse on channel 2 is 50 μs ±10 μs. Check that the negative-going edge of the pulse on channel 2 is at least 1 ms after the negative-going edge of the pulse on channel 1.

(7) Set the PHASE SHIFT control fully counter-clockwise and check that the negative-going edge of the channel 2 pulse moves to at least 0.9 ms before the negative-going edge of the channel 1 pulse. Check that the channel 2 pulse has an amplitude of at least 4 V peak.

(8) Reset the oscillator to 50 Hz sine wave and check with the oscilloscope that the sweep generator input is 50 Hz ±2 Hz, 4.8 V p-p.

(9) Set the PHASE SHIFT control fully clockwise and check that the negative-going edge of the channel 2 pulse is at least 5 ms after the negative-going edge of the channel 1 pulse.

(10) Set the PHASE SHIFT control fully counter-clockwise and check that the negative-going edge of the channel 2 pulse is at least 10 ms before the negative-going edge of the channel 1 pulse.

(11) Set the oscillator output to 40 Hz sine wave at the same level. Set the oscilloscope to channel 2 operation, internal positive trigger, and connect it to the X-DRIVE OUTPUT socket. Set the VARIABLE RATE control fully clockwise and check that the sweep time (sweep plus flyback) is less than 14.3 ms, on ratios of both 1:1 and 10:1.

(12) Set the oscilloscope time base to 2 ms/cm. Adjust RV2 on board 8 for the best compromise to give a clean waveform on both 1:1 and 10:1 ratios, especially for least rounding at the transition from sweep to flyback; also to give a d.c. level for the waiting time that is within ±1 V of the negative peak voltage noted in 5.8.4 (5).

(13) Adjust the VARIABLE RATE control for minimum stable waiting time, and check that this does not exceed 400 μs on either 1:1 or 10:1 ratio. Disconnect the R C oscillator.

(14) Set the SWEEP FUNCTION switch to MAINS LOCK and check that the X-DRIVE OUTPUT is at least 30.5 V p-p.

(15) Adjust the VARIABLE RATE control for minimum stable waiting time, and check that this does not exceed 400 μs on either 1:1 or 10:1 ratio. Display at least 3 cycles of the ramp output and check that each cycle is equal in time.

5.7.6 Blanking

Test equipment: a, b and c

(1) Set the SWEEP FUNCTION switch to 0.01 - 0.1 Hz, RATIO switch to 1:1 and VARIABLE RATE control fully clockwise. Connect the oscilloscope (fitted with the type W plug-in) to pin 9 on the

dummy load. Check that the waveform displayed is a square wave of at least +21 V amplitude. Repeat for the other three internal ranges of the SWEEP FUNCTION switch, also for the MAINS LOCK position. In each case set the BLANKING switch to OFF and check that the trace indicates a steady d.c. level of at least +21 V.

(2) Check the blanking output as detailed in Chap. 4, Sect. 4.4.6.

5.7.7 External drive and manual control

Test equipment: a, b, c, f, m and s

(1) Set the SWEEP FUNCTION switch to EXTERNAL and the EXTERNAL DRIVE SET LEVEL control fully clockwise. Connect the oscilloscope to pin 14 on the dummy load and set it up for comparative voltage checking as in 5.8.3 (15). Adjust the trace to the lowest line on the graticule and switch input A to d.c. Set the digits on the oscilloscope plug-in for a Vc of 187.5 mV (i.e. 1 on the outer knob, 8 in the middle window and 75 on the inner scale).

(2) Short circuit the external drive input socket and adjust RV3 on the external drive amplifier board (board 9) until the trace is on the lowest line of the graticule ±1 mV. Remove the short circuit.

(3) Set the SWEEP FUNCTION switch to MANUAL and the VARIABLE RATE control fully counter-clockwise. Set the digits on the oscilloscope to 33.75 and adjust RV1 and RV2 on board 9 progressively until this value is obtained within 1 mV (note that RV1 and RV2 interact).

(4) Set the VARIABLE RATE control fully clockwise and set the digits on the oscilloscope to 341.25 mV. Adjust RV1 and RV2 progressively until this value is obtained within 1 mV.

(5) Repeat (3) and (4) until both conditions are satisfied.

(6) Reset the oscilloscope for normal operation and connect it to the X-DRIVE OUTPUT socket loaded with the 50 kΩ resistor. Set the SWEEP FUNCTION switch to EXTERNAL and connect the v.l.f. oscillator to the EXTERNAL DRIVE INPUT socket. Set the oscillator to 0.01 Hz, 4 V p-p symmetrical about earth.

(7) Check that the X-drive output is at least 30.5 V and repeat with the oscillator set to 0.1 Hz and 1 Hz.

(8) Disconnect the v.l.f. oscillator and connect the RC oscillator in its place. Set the oscillator to 10 Hz sine wave, 4 V p-p output, 75 Ω source.

(9) Check that the X-drive output is at least 30.5 V, and repeat with the oscillator set to 100 Hz, 200 Hz, 2 kHz, 10 kHz and 20 kHz.

5.7.8 Marker adder

Test equipment: b, c, p and q

(1) Turn the SUPPLY switch OFF, remove the dummy load and fit the video plug-in unit into the main unit. Turn the SUPPLY switch ON and connect the oscilloscope to the COMBINED OUTPUT socket.

(2) Adjust RV2 (coarse) and RV1 (fine) on the marker adder board (board 6) for zero d.c. output ±5 mV.

(3) Connect the input of the video detector to the VIDEO OUTPUT socket on the video sweep unit, and the output of the detector to the DETECTED INPUT socket. Put the MARKER switch ON, and check that markers are displayed with detected video on the oscilloscope. Switch the markers OFF and check that detected video only is displayed. Switch power supplies OFF and disconnect all test equipment.

5.8 FAULT FINDING

Fault finding techniques should follow standard electronic practice, and this section is confined to giving some guidance on possible causes of failure to meet specified performance, in tabular form related to the information given in Sect. 5.8. Voltages are quoted on the circuit diagrams in Chap. 7. In addition, the waveforms illustrated in Figs. 3.2 to 3.10 will be found useful as an aid to fault finding.

5.8.1 Performance failures

Failure to meet performance figures quoted in section	*Possible causes*
5.7.2 (3)	VT1 faulty; if VT1 is short circuited, suspect VT6 is damaged.
5.7.3 (5)	Faulty smoothing capacitors on rectifier board, also C1 or C5 on board 4.
5.7.2 (10)	VT1 faulty.
5.7.3 (5) & (6)	Protection diode across capacitor faulty.
5.7.3 (8)	MR3, MR12, MR7 or MR9 faulty.
5.7.3 (13)	Relevant timing capacitor(s) faulty.
5.7.3 (18)	VT9, MR19 or associated resistors faulty.
5.7.4 (2)	MR1, R1 or MR4 faulty (amplitude); VT1, VT2 or feedback resistors faulty (equality).
5.7.4 (5)	VT8 or VT10 in differential amplifier faulty.
5.7.4 (6)	Lack of linearity on any one sweep range indicates a faulty timing capacitor; on all ranges, general fault in control oscillator.
5.7.5 (2)	C3, R8 faulty (width); VT3 faulty (amplitude); VT3 faulty (rise time).
5.7.5 (6)	Mainly general, but suspect first R28, R29, C15, R21 & R22.
5.7.5 (12)	VT14, 15, 16 or 17 faulty; also suspect all diodes.
5.7.6 (1)	VT1 or VT2 faulty; if spikes are present, suspect MR3 or MR4 faulty.
5.7.6 (2)	Faulty reference supply from VT9 on control oscillator board.
5.7.8 (2)	Leakage fault on VT2, or faulty VT3.

5.8.2 Circuit voltages

The voltages given on the circuit diagrams were taken on a typical TF 2361 using an oscilloscope with a 10:1 probe, giving an input resistance of 10 MΩ. All measurements are with respect to earth.

Conditions: SWEEP FUNCTION switch at C.W., VARIABLE RATE control fully clockwise, PHASE SHIFT control fully counter clockwise, RATIO switch at 10:1.

Chapter 6

Replaceable parts

Introduction

This chapter lists replaceable parts in alphabetical order of their circuit references, and in the order of the sub-assembly and printed circuit board numbers, as follows:

1	:	Main chassis and front panel
2	:	110 V oscillator board
3	:	110 V supply board
4	:	±24 V supplies board
5	:	TV sync separator board
6	:	Marker adder board
7	:	X-drive amplifier board
8	:	Sync trigger and binary board
9	:	External drive and blanking board
10	:	Control oscillator and differential amplifier board
11	:	Rectifiers

When ordering parts or referring to them in correspondence, use the board number to prefix the circuit reference number, for example 7R1, 10MR16. The following abbreviations are used in the list of replaceable parts:

C	:	capacitor
C*	:	capacitor selected for low leakage current
Carb	:	carbon
Cer	:	ceramic
Elec	:	electrolytic
FS	:	fuse
L	:	inductor
Lin	:	linear
MR	:	semiconductor diode
PL	:	plug
PLP	:	pilot lamp
Plas	:	plastic
R	:	resistor
RV	:	variable resistor
S	:	switch
SKT	:	socket
T	:	transformer
TP	:	terminal
VT	:	transistor
VT*	:	transistor selected for high current gain
W	:	watts at 70 °C
W*	:	watts at 40 °C
WW	:	wirewound
⌀	:	feed-through component

Ordering

Send your order for replaceable parts to our Service Division at the address given on the back cover. Specify the following information for each part required:

1) Type and serial number of instrument
2) Circuit reference
3) Description
4) M.I. code number

If a part is not listed, state its function, location and description when ordering.

Circuit reference	*Description*	*M.I. code*
Unit (1) Front panel and chassis		
When ordering, prefix circuit reference with 1		
FS1	Glass cartridge 250mA (230V), time-lag	23411-055
	Glass cartridge 500mA (115V), time-lag	23411-056
FS2	Glass cartridge 250mA (230V), time-lag	23411-055
	Glass cartridge 250mA (115V), time-lag	23411-056
FS3	Glass cartridge 1A, time-lag	23411-058
FS4	Glass cartridge 1A, time-lag	23411-058
FS5	Glass cartridge 1A, time-lag	23411-054
L1	10μH 10%	23642-555G
L2	10μH 10%	23642-555G
L3	10μH 10%	23642-555G
PL1	3-pin mains	23423-151
PLP1	100V neon indicator	23733-150

Circuit reference	Description	M.I. code
RV1	WW double gan 10kΩ/2kΩ 5% 1W Lin.	25872-385
SA	Sweep function	44325-903
SB	ALC int/ext.	23462-252
SC	Marker on/off	23462-252
SD	Blanking on/off	23462-258
SE	Sweep mode normal - one shot	23462-266
SF	One shot (biased)	23462-253
SG	Supply on/off	44334-003
SH	Supply range 115V-230V	23467-155
SKT1	24-pin	23435-640
SKT2	BNC 50Ω coaxial	23443-443
SKT3	BNC 50Ω coaxial	23443-443
SKT4	BNC 50Ω coaxial	23443-443
SKT5	BNC 50Ω coaxial	23443-443
SKT6	BNC 50Ω coaxial	23443-443
SKT7	BNC 50Ω coaxial	23443-443
T1	Mains transformer	43467-702
TP1	Miniature red	23235-204
TP2	Miniature black	23235-205
TP3	Miniature red	23235-204

Unit (2) 110 V oscillator

When ordering, prefix circuit reference with 2

Complete board		44823-260
C1	Paper 0.02μF 10% 200V	26174-151
C2	Cer 100pF 2% 750V	26324-897
C3	Paper 500pF 20% 600V	26174-122
C4	Paper 0.001μF 10% 500V	26174-125
C5	Paper 0.001μF 10% 500V	26174-125
C6	Paper 0.003μF 10% 350V	26174-133
C7	Cer ϕ 4700pF +80-20% 500V	26373-665
C8	Cer ϕ 4700pF +80-20% 500V	26373-665
C9	Cer ϕ 4700pF +80-20% 500V	26373-665
MR1	1N 914	28336-676
R1	Carb 470Ω 5% ¼W	24312-869
R2	Carb 39kΩ 5% ¼W	24312-924
R3	Carb 220Ω 5% ¼W	24312-858
R4	Carb 220Ω 5% ¼W	24312-858
R5	Carb 47Ω 5% ¼W	24312-837
T1	Transformer	43557-002
VT1	BCY 70 (Special)	44529-002
VT2	2N 4240	28458-657

Unit (3) 110 V supply

When ordering, prefix circuit reference with 3

Complete board		44823-259
C1	Elec 100μF +50-20%	26417-495
C2	Elec 4μF +100-20% 50V	26423-305
MR1	1S 923	28356-018
MR2	1S 923	28356-018
MR3	1S 44	28357-548
R1	Carb 18kΩ 1% ½W	24155-180
R2	Carb 4.7kΩ 1% ¼W	24134-470
R3	WW 1kΩ 5% 1½W	25123-080
R4	WW 10kΩ 5% 3W	25125-110
R5	Carb 2.2kΩ 5% ¼W	24312-888

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R6	Carb 2.2kΩ 5% ¼W	24312-888
R7	Carb 15kΩ 5% ¼W	24312-914
R8	Carb 1.8kΩ 5% ¼W	24312-886
R9	WW 330Ω 5% 3W	25125-063
R10	Carb 1kΩ 5% ¼W	24312-880
RV1	WW 1kΩ 10% 1W Lin.	25811-538
VT1	BCY 70	28434-857
VT2	BCY 70	28434-857
VT3	BCY 70	28434-857

Unit (4) 24 V supplies

When ordering, prefix circuit reference with 4

Complete board		44823-258
C1	Elec 250µF +100-20% 35V	26417-168
C2	Elec 2µF +100-20% 25V	26414-109
C3	Elec 2µF +100-20% 25V	26414-109
C4	Elec 25µF +100-20% 25V	26423-311
C5	Elec 250µF +100-20% 35V	26417-168
C6	Elec 2µF +100-20% 25V	26414-109
C7	Elec 2µF +100-20% 25V	26414-109
MR1	Z1B 6.2	28371-488
MR2	Z1B 5.6	28371-439
R1	WW 2.2Ω 10% 1½W	25133-006
R2	Carb 470Ω 5% ¼W	24312-869
R3	Carb 8.2kΩ 5% ¼W	24312-908
R4	Carb 15kΩ 5% ¼W	24312-914
R5	Carb 470Ω 5% ¼W	24312-869
R6	WW 680Ω 5% 1½W	25123-075
R7	Carb 2.2kΩ 5% ½W	24313-888
R8	Carb 470Ω 5% ¼W	24312-869
R9	Carb 2kΩ 5% ¼W	24312-887
R10	Carb 1.8kΩ 5% ¼W	24312-886
R11	Carb 100Ω 5% ¼W	24312-850
R12	Carb 4.7kΩ 5% ¼W	24312-900
R13	Carb 4.7kΩ 5% ¼W	24312-900
R14	Carb 4.7kΩ 5% ¼W	24312-900
R15	Carb 220kΩ 5% ¼W	24312-943
R16	Carb 470Ω 5% ¼W	24312-869
R17	Carb 1.2kΩ 5% ¼W	24312-882
R18	WW 2.2Ω 10% 1½W	25133-006
R19	Carb 470Ω 5% ¼W	24312-869
R20	Carb 12kΩ 5% ¼W	24312-912
R21	Carb 15kΩ 5% ¼W	24312-914
R22	Carb 1.2kΩ 5% ½W	24313-882
R23	Carb 470Ω 5% ¼W	24312-869
R24	Carb 470Ω 5% ½W	24313-869
R25	Carb 390Ω 5% ½W	24313-865
R26	Carb 390Ω 5% ½W	24313-865
R27	Carb 470Ω 5% ¼W	24312-869
R28	Carb 10kΩ 5% ¼W	24312-910
R29	Carb 10kΩ 5% ¼W	24312-910
R30	Carb 10kΩ 5% ¼W	24312-910
R31	Carb 220Ω 5% ¼W	24312-858
R32	Carb 47kΩ 5% ¼W	24312-926
R33	Carb 10kΩ 5% ¼W	24312-910
R34	Carb 4.7kΩ 5% ¼W	24312-900
R35	Carb 4.3kΩ 5% ¼W	24312-898
RV1	WW 500Ω 10% 1W Lin.	25811-535
RV2	WW 1kΩ 10% 1W Lin.	25811-538
VT1	BCY 70	28434-857
VT2	BCY 70	28434-857
VT3	BCY 70	28434-857
VT4	BCY 70	28434-857

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
VT5	BCY 70	28434-857
VT6	NKT 403	28423-924
VT7	BCY 70	28434-857
VT8	BCY 70	28434-857
VT9	BCY 70	28434-857
VT10	BCY 70	28434-857
VT11	BCY 70	28434-857
VT12	NKT 403	28423-924

Unit (5) TV sync separator

When ordering, prefix circuit reference with 5

Complete board		44823-256
C1	Cer 0.1μF +50-25% 30V	26383-031
C2	Paper 0.003μF 10% 350V	26174-133
C3	Paper 0.033μF 10% 250V	26582-205
C4	Elec 25μF +100-20% 18V	26417-141
C5	Cer ϕ 0.001μF +80-20% 500V	26373-714
MR1	Z1B 5.6	28371-439
MR2	Z1B 4.7	28371-377
R1	Carb 75Ω 5% ¼W	24312-844
R2	Carb 270kΩ 5% ¼W	24312-946
R3	Carb 47kΩ 5% ¼W	24312-926
R4	Carb 3.9kΩ 5% ¼W	24312-896
R5	Carb 12kΩ 5% ¼W	24312-912
R6	Carb 2.2kΩ 5% ¼W	24312-888
R7	Carb 20kΩ 5% ¼W	24312-917
R8	Carb 1.5kΩ 5% ¼W	24312-884
R9	Carb 4.7kΩ 5% ¼W	24312-900
R10	Carb 2.7kΩ 5% ¼W	24312-892
VT1	BCY 70	28434-857
VT2	BCY 70	28434-857
VT3	BC 107	28455-437

Unit (6) Marker adder

When ordering, prefix circuit reference with 6

Complete board		44823-112
MR1	1N 914	28336-676
R1	Carb 1MΩ 5% ¼W	24312-966
R2	Carb 56kΩ 5% ¼W	24312-929
R3	Carb 6.8kΩ 5% ¼W	24312-906
R4	Carb 11kΩ 5% ¼W	24312-911
R5	Carb 12kΩ 5% ¼W	24312-912
R6	Carb 22kΩ 5% ¼W	24312-918
R7	Carb 9.1kΩ 5% ¼W	24312-909
R8	Carb 10kΩ 5% ¼W	24312-910
R9	Carb 18kΩ 5% ¼W	24312-916
R10	Carb 4.7kΩ 5% ¼W	24312-900
RV1	Carb 220Ω 20% ¼W Lin.	25611-068
RV2	WW 3.3kΩ 10% 1W Lin.	25811-022
VT1	BC 107	28455-437
VT2	MPF 104 (selected for V_{GS})	28459-009W
VT3	BC 109	28452-777
VT4	BCY 70	28434-857

Unit (7) X-drive amplifier

When ordering, prefix circuit reference with 7

Complete board		44823-251
MR1	Z5B 15	28372-303
MR2	1N4148	28336-676
MR3	1N4148	28336-676
MR4	Z5B 4.3	28371-313
R1	Carb 9kΩ 1% ¼W	24134-900

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R2	Met ox 1.5kΩ 2% ¼W	24773-277
R3	Carb 22kΩ 5% 2W*	24316-718
R4	Met ox 75Ω 2% ¼W	24773-246
R5	Met ox 47Ω 2% ¼W	24773-241
R6	Carb 22kΩ 5% 2W*	24316-718
R7	Met ox 33kΩ 2% ¼W	24773-309
R8	Met ox 33kΩ 2% ¼W	24773-309
R9	Met ox 4.3kΩ 2% ¼W	24773-288
RV1	WW 470Ω 10% 1W Lin.	25811-017
RV2	WW 1kΩ 10% 1W Lin.	25811-019
RV3	WW 25kΩ 10% 1W Lin.	25815-376
SA	SPDT toggle	23462-252
VT1	BC 107	28455-437
VT2	BC 107	28455-437

Unit (8) Sync trigger and binary

When ordering, prefix circuit reference with 8

Complete board		44823-262
C1	Elec 50µF +100-20% 25V	26423-317
C2	Paper 0.01µF 10% 200V	26174-145
C3	Plas 0.33µF 10% 250V	26512-256
C4	Elec 100µF +100-20% 25V	26423-327
C5	Paper 0.0055µF 2% 125V	26516-666
C6	Plas 0.047µF 5% 160V	26511-337
C7	Elec 1000µF +100-20% 18V	26417-183
C8	Elec 2µF +100-20% 25V	26414-109
C9	Paper 0.0055µF 2% 125V	26516-666
C10	Paper 0.03µF 10% 200V	26174-155
C11	Plas 470pF 2% 125V	26516-406
C12	Plas 470pF 2% 125V	26516-406
C13	Paper 0.001µF 10% 500V	26174-125
C14	Elec 100µF +100-20% 25V	26423-327
C15	Elec 6.8µF 20% 6V	26487-274
MR1	1S 44	28357-548
MR2	1S 44	28357-548
MR3	1S 44	28357-548
MR4	1S 44	28357-548
MR5	Z1B 12	28372-147
MR6	1S 44	28357-548
MR7	1S 44	28357-548
MR8	1S 44	28357-548
MR9	Not used	
MR10	CG 85 H	28321-201
MR11	1S 44	28357-548
MR12	1S 44	28357-548
MR13	Z1B 6.8	28371-547
R1	Carb 1kΩ 5% ¼W	24312-880
R2	Carb 12kΩ 5% ¼W	24312-912
R3	Carb 10kΩ 5% ¼W	24312-910
R4	Carb 10kΩ 5% ¼W	24312-910
R5	Carb 2.7kΩ 5% ¼W	24312-892
R6	Carb 4.7kΩ 5% ¼W	24312-900
R7	Carb 1.5kΩ 5% ¼W	24312-884
R8	Carb 22kΩ 5% ¼W	24312-918
R9	Carb 39kΩ 5% ¼W	24312-924
R10	Carb 2.2kΩ 5% ¼W	24312-888
R11	Carb 1kΩ 5% ¼W	24312-880
R12	Carb 10kΩ 5% ¼W	24312-910
R13	Carb 10kΩ 5% ¼W	24312-910
R14	Carb 270kΩ 5% ¼W	24312-946
R15	Carb 3.9kΩ 5% ¼W	24312-896
R16	Carb 33kΩ 5% ¼W	24312-922
R17	Carb 7.5kΩ 5% ¼W	24312-907
R18	Carb 10kΩ 5% ¼W	24312-910
R19	Carb 2kΩ 5% ¼W	24312-887

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R20	Carb 680Ω 5% ¼W	24312-876
R21	Carb 15kΩ 5% ¼W	24312-914
R22	Carb 8.2kΩ 5% ¼W	24312-908
R23	Carb 1kΩ 2% ¼W	24352-880
R24	Carb 5.6kΩ 2% ¼W	24352-903
R25	Carb 47kΩ 5% ¼W	24312-926
R26	Carb 15kΩ 5% ¼W	24312-914
R27	Carb 10kΩ 5% ¼W	24312-910
R28	Carb 36kΩ 2% ¼W	24352-923
R29	Carb 220Ω 5% ¼W	24312-858
R30	Carb 68kΩ 5% ¼W	24312-931
R31	Carb 22kΩ 5% ¼W	24312-918
R32	Carb 5.6kΩ 5% ¼W	24312-903
R33	Carb 68kΩ 5% ¼W	24312-931
R34	Carb 12kΩ 5% ¼W	24312-912
R35	Carb 24kΩ 5% ¼W	24312-919
R36	Carb 39kΩ 5% ¼W	24312-924
R37	Carb 39kΩ 5% ¼W	24312-924
R38	Carb 27kΩ 5% ¼W	24312-920
R39	Carb 100kΩ 5% ¼W	24312-935
R40	Carb 10kΩ 5% ¼W	24312-910
R41	Carb 100kΩ 5% ¼W	24312-935
R42	Carb 2kΩ 5% ¼W	24312-887
R43	Carb 12kΩ 5% ¼W	24312-912
R44	Carb 27Ω 5% ¼W	24312-831
R45	Carb 5.6kΩ 5% 1/8W	24311-891T
RV1	WW 10kΩ 5% 1W Lin.	25815-051
RV2	WW 4.7kΩ 10% 1W Lin.	25811-023
RV3	Carb 5kΩ 10% 0.21W Lin.	25541-375L
VT1	BC 107	28455-437
VT2	BC 107	28455-437
VT3	BC 107	28455-437
VT4	BC 107	28455-437
VT5	BCY 70	28434-858
VT6	BCY 70	28434-858
VT7	BC 107	28455-437
VT8	BCY 70	28434-858
VT9	BC 107	28455-437
VT10	BC 107	28455-437
VT11	BC 107	28455-437
VT12	BC 107	28455-437
VT13	BC 107	28455-437
VT14	BC 107	28455-437
VT15	BC 107	28455-437
VT16*	TCH 98	28434-813
VT17	BC 107	28455-437

Unit (9) External drive and blanking

When ordering, prefix circuit reference with 9

Complete board		44823-261
C1	Plas 0.0022μF 2% 125V	26516-564
L1	100μH 10%	23642-561
MR1	1S 923	28356-018
MR2	1S 923	28356-018
MR3	1N 914	28336-676
MR4	1N 914	28336-676
R1	Carb 270kΩ 5% ¼W	24312-946
R2	Carb 12kΩ 5% ¼W	24312-912
R3	Carb 10kΩ 5% ¼W	24312-910
R4	Carb 10kΩ 5% ¼W	24312-910
R5	Carb 1.3kΩ 5% ½W	24313-883
R6	Carb 56Ω 5% ¼W	24312-840
R7	Carb 1kΩ 5% ½W	24313-880

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R8	Carb 3.9kΩ 1% ¼W	24134-390
R9	Carb 3.9kΩ 1% ¼W	24134-390
R10	Carb 6.8kΩ 1% ¼W	23134-680
R11	Carb 430Ω 5% ¼W	24312-867
R12	Carb 2.2kΩ 1% ¼W	24134-220
R13	Carb 430Ω 5% ¼W	24312-867
R14	Carb 6.8kΩ 5% ¼W	24312-906
R15	Carb 200Ω 5% ¼W	24312-857
R16	Carb 68kΩ 5% ¼W	24312-931
R17	Carb 33kΩ 5% ¼W	24312-922
R18	Carb 11kΩ 1% ¼W	24135-110
R19	Carb 2kΩ 1% ¼W	24134-200
R20	Carb 22kΩ 1% ¼W	24135-220
R21	Carb 9kΩ 1% ¼W	24134-900
R22	Carb 2kΩ 5% ½W	24313-887
RV1	WW 3.3kΩ 10% 1W Lin.	25811-022
RV2	WW 4.7kΩ 10% 1W Lin.	25811-023
RV3	WW 3.3kΩ 10% 1W Lin.	25811-022
RV4	WW 500Ω 10% 1W Lin.	25815-106
VT1	BC 107	28455-437
VT2	BSX 36	28434-867
VT3	BC 107	28455-437
VT4	BC 107	28455-437
VT5	BC 107	28455-437
VT6	BC 107	28455-437
VT7	BCY 70	28434-857

Unit (10) Control oscillator and differential amplifier

When ordering, prefix circuit reference with 10

Complete board		44823-250
C1	Elec 50μF +100-20% 50V	26423-319
C2	Elec 50μF +100-20% 50V	26423-319
C3	Elec 50μF +100-20% 50V	26423-319
C4	Elec 50μF +100-20% 50V	26423-319
C5	Elec 4μF +100-20% 50V	26423-305
C6	Elec 4μF +100-20% 50V	26423-305
C7	Elec 4μF +100-20% 50V	26423-305
C8	Elec 4μF +100-20% 50V	26423-305
C9	Elec 2μF +100-20% 70V	26412-212
C10	Plas 0.33μF 5% 60V	26551-221
C11	Plas 0.68μF 5% 60V	26551-229
C12	Plas 3.3μF 5% 60V	26551-242
C13*	Elec 68μF 10% 15V	44435-024
C14*	Elec 68μF 10% 15V	44435-024
C15*	Elec 330μF 10% 6V	44435-023
C16*	Elec 330μF 10% 6V	44435-023
C17*	Elec 330μF 10% 6V	44435-023
C18*	Elec 330μF 10% 6V	44435-023
MR1	Z5H 5.1	28371-404
MR2	1S 923	28356-018
MR3	Z1B 6.8	28371-547
MR4	Z1B 8.2	28371-677
MR5	Z1B 10	28371-847
MR6	1S 44	28357-548
MR7	1S 44	28357-548
MR8	1S 44	28357-548
MR9	1S 44	28357-548
MR10	Not used	
MR11	Not used	
MR12	Z1B 10	28371-847
MR13	1S 44	28357-548
MR14	1N 4004	28357-028
MR15	1S 923	28356-018
MR16	1S 923	28356-018
MR17	1S 923	28356-018
MR18	1S 923	28356-018
MR19.	1S 923	28356-018

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R1	Carb 24kΩ 5% ¼W	24312-919
R2	Carb 2.7kΩ 5% ¼W	24312-892
R3	Carb 4.3kΩ 5% ¼W	24312-898
R4	Carb 3.3kΩ 5% ¼W	24312-894
R5	Carb 22kΩ 5% ¼W	24312-918
R6	Carb 1.5kΩ 5% ¼W	24312-884
R7	Carb 47Ω 5% ¼W	24312-837
R8	Carb 1.5kΩ 2% ¼W	24352-884
R9	Carb 47kΩ 5% ¼W	24312-926
R10	Carb 5.6kΩ 1% ¼W	24134-560
R11	Carb 10kΩ 1% ¼W	24135-100
R12	Carb 560Ω 5% ¼W	24312-872
R13	Carb 270kΩ 5% ¼W	24312-946
R14	Carb 5.6kΩ 1% ¼W	24134-560
R15	Carb 1kΩ 1% ¼W	24134-100
R16	Carb 560Ω 5% ¼W	24312-872
R17	Carb 270kΩ 5% ¼W	24312-946
R18	Carb 47kΩ 5% ¼W	24312-926
R19	Carb 24kΩ 5% ¼W	24312-919
R20	Carb 4.7kΩ 5% ¼W	24312-900
R21	Carb 680Ω 5% ¼W	24312-876
R22	Carb 1MΩ 5% ¼W	24312-966
R23	Carb 1.5kΩ 5% ¼W	24312-884
R24	Carb 1.8kΩ 1% ¼W	24134-180
R25	Carb 6.2kΩ 1% ¼W	24134-620
R26	Carb 33kΩ 5% ¼W	24312-922
R27	Carb 56kΩ 5% ¼W	24312-929
R28	Carb 1kΩ 1% ¼W	24134-100
R29	Carb 1kΩ 5% ¼W	24312-880
R30	Carb 1kΩ 5% ¼W	24312-880
R31	Carb 5.1kΩ 5% ¼W	24312-902
R32	Carb 1.5kΩ 5% ¼W	24312-884
R33	Carb 43kΩ 5% ¼W	24312-925
R34	Carb 56kΩ 5% ¼W	24312-929
RV1	WW 3.3kΩ 10% 1W Lin.	25811-022
RV2	WW 4.7kΩ 10% 1W Lin.	25811-023
RV3	Carb 100Ω 10% 0.4W Lin.	25541-366

Circuit reference	Description	M.I. code
SA	Ratio 1:1 - 10:1	23462-258
VT1	BCY 70	28434-857
VT2	BCY 70	28434-857
VT3*	TCH 98	28434-813
VT4	BCY 70	28434-857
VT5*	TCH 98	28434-813
VT6	BCY 70	28434-857
VT7	BC 107	28455-437
VT8	BCY 70	28434-857
VT9	BCY 70	28434-857
VT10	BCY 70	28434-857
VT11	BC 107	28455-437
VT12	BC 107	28455-437
VT13	BC 107	28455-437

Unit (11) Rectifiers

When ordering, prefix circuit reference with 11

Complete board		44823-249
C1	Elec 1000μF +100-20% 25V	26417-406
C2	Elec 2500μF +50-20% 50V	26427-134
C3	Elec 2500μF +50-20% 50V	26427-134
C4	Elec 500μF +50-20% 250V	26427-110
MR1 to MR4	1S 923	28356-018
MR5 to MR16	1N 4004	28357-028
R1	Carb 100kΩ 5% ¼W	24312-935

For symbols and abbreviations see introduction to this chapter

Chapter 7

Circuit diagrams

Circuit notes

1. COMPONENT VALUES

Resistors: No suffix = ohms, k = kilohms, M = megohms.
Capacitors: No suffix = microfarads, p = picofarads.
* value selected during test, nominal value shown.

2. VOLTAGES

Shown in italics adjacent to the point to which the measurement refers. See section 5.8.2 for conditions.

3. SYMBOLS

+► arrow indicates clockwise rotation of knob.

RANGE etc., external front or rear panel marking.

preset control.

(26) unit identification number.

a-d letters associated with switch contacts refer to the switch key sketch and indicate the knob settings at which the connection is made.

A point marked with this symbol is connected to and receives power from point marked with this symbol A

These symbols are used to identify branches of the power supply circuitry but have no particular physical reality on the printed boards.

4. CIRCUIT REFERENCES

These are, in general, given in abbreviated form.
See also introduction to chapter 6.

5. SWITCHES

Rotary switches are drawn schematically.
Letters indicate control knob settings.
1F = 1st section (front panel), front
1B = 1st section, back
2F = 2nd section, front
etc.

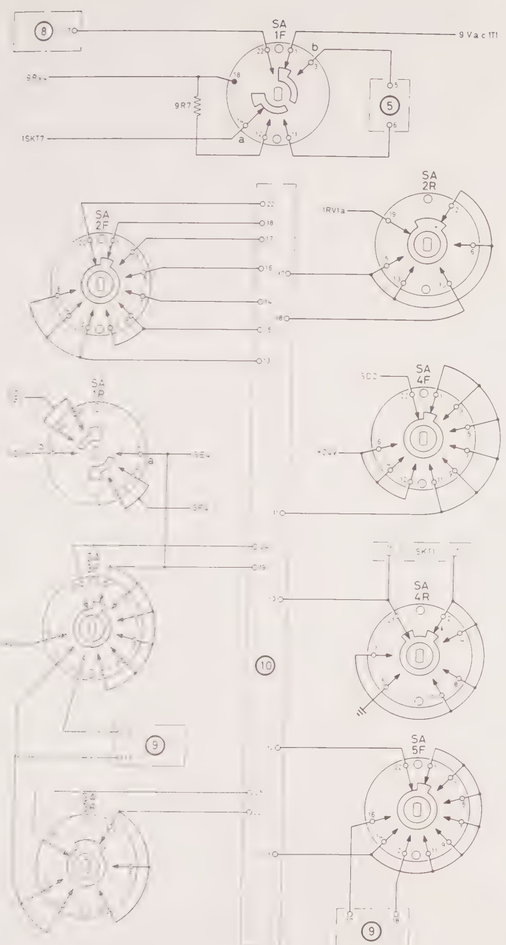


Fig. 7.1 SA plan of sections viewed from knob end with switch in fully counter-clockwise position

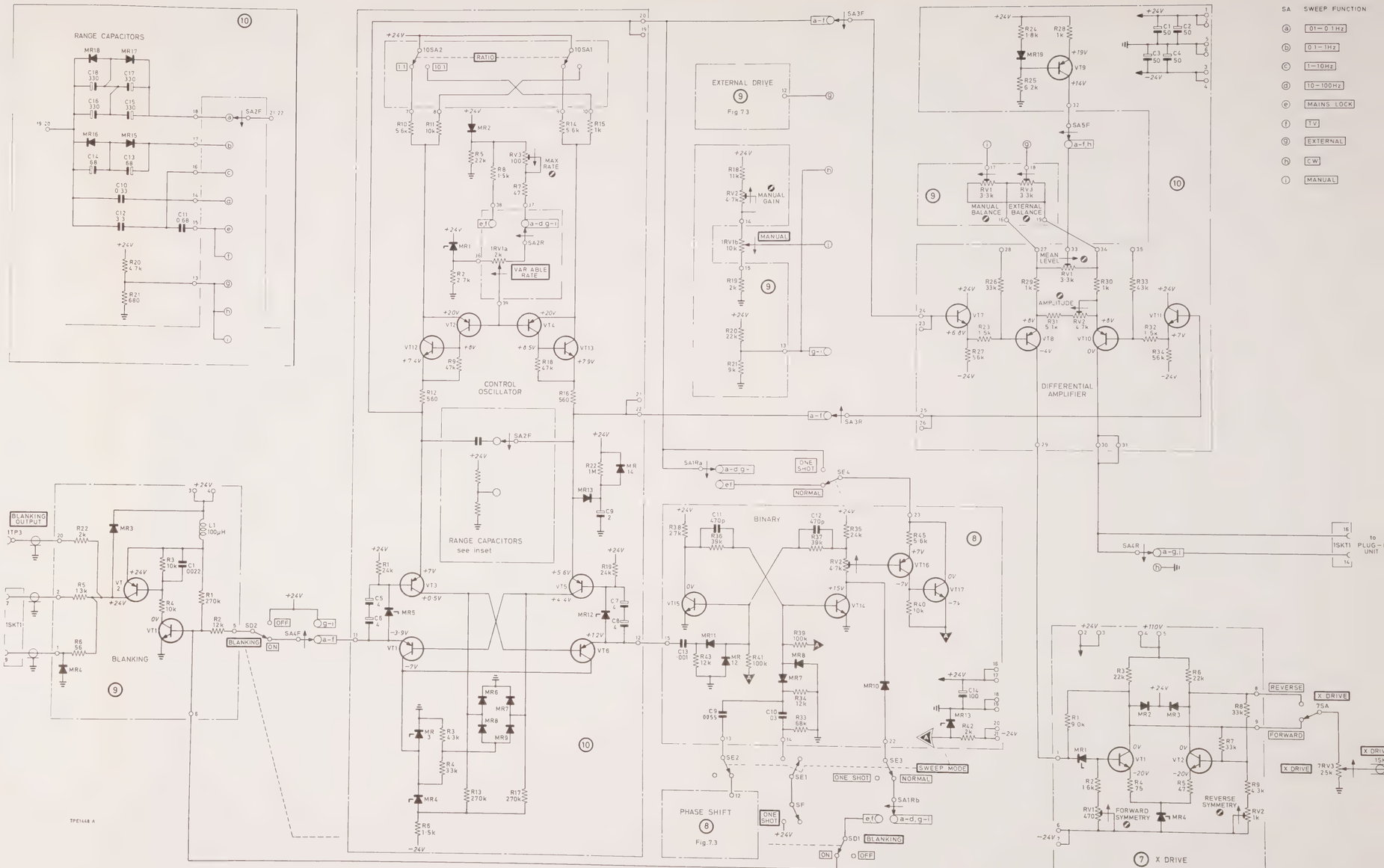
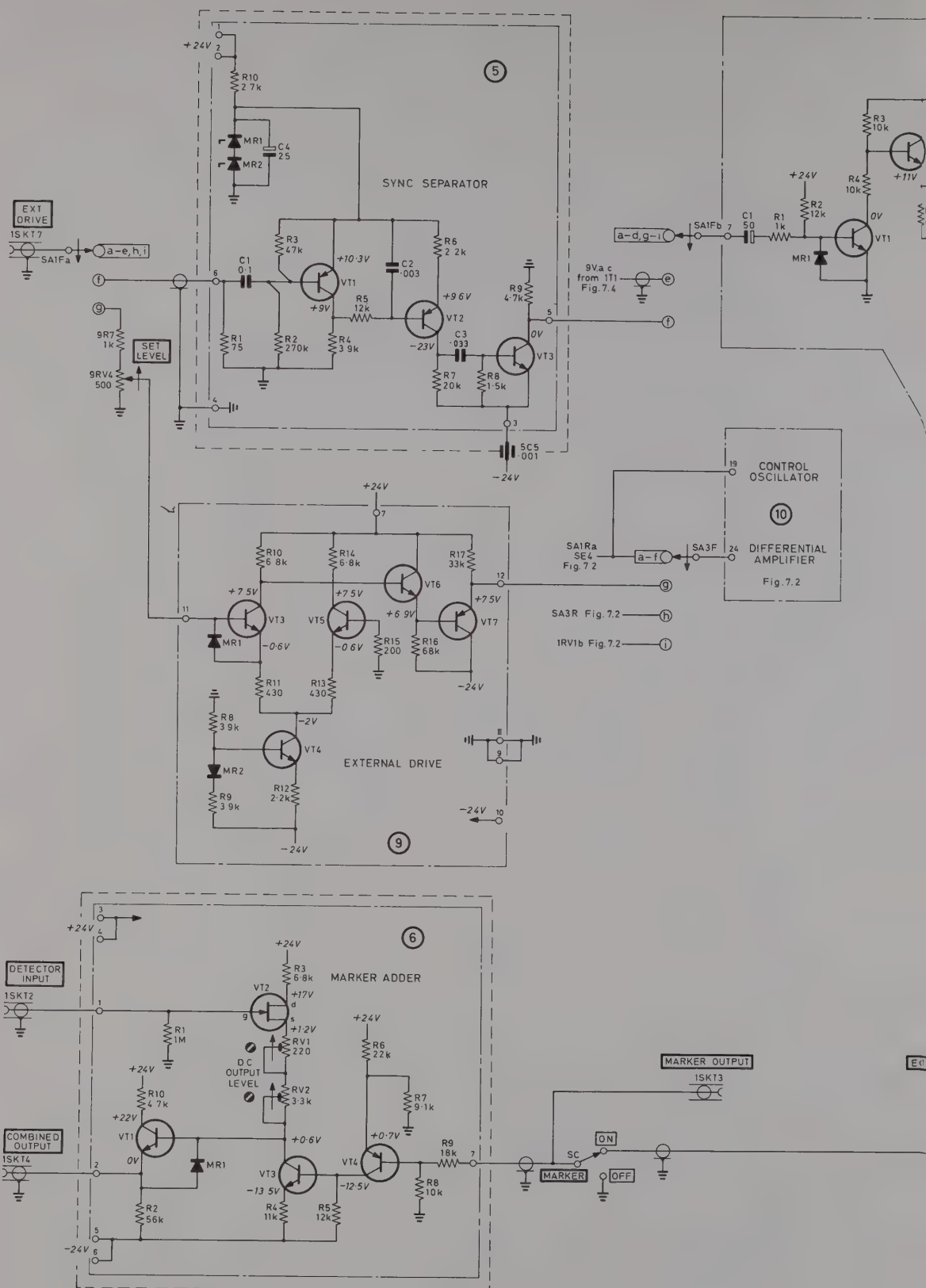


Fig. 7.2 Circuit diagram— control oscillator and drive, blanking and binary


5
SYNC SEPARATOR
+24V
R10 2·7k
MR1
MR2
C4 25
EXT DRIVE
1SKT7
SA1Fa
a-e,h,i
C1 0·1
R3 47k
+10·3V
VT1
+9V
C2 ·003
R6 2·2k
+9·6V
R5 12k
VT2
-23V
C3 ·033
R9 4·7k
0V
VT3
R1 75
R2 270k
R4 3·9k
R7 20k
R8 1·5k
9R7 1k
SET LEVEL
9RV4 500
5C5 ·001
-24V
9V a.c from 1T1 Fig.7.4
SA1Fb
a-d,g-i
C1 50
R1 1k
R2 12k
R3 10k
R4 10k
+11V
MR1
CONTROL OSCILLATOR
10
DIFFERENTIAL AMPLIFIER
Fig.7.2
SA1Ra SE4 Fig.7.2
a-f
SA3F
SA3R Fig.7.2
1RV1b Fig.7.2
R10 6·8k
R14 6·8k
R17 33k
VT6
+7·5V
VT3
VT5
+6·9V
VT7
MR1
-0·6V
R15 200
R16 68k
R11 430
R13 430
-2V
R8 3·9k
VT4
MR2
R9 3·9k
R12 2·2k
EXTERNAL DRIVE
9
6
MARKER ADDER
DETECTOR INPUT
1SKT2
R1 1M
R3 6·8k
+17V
+1·2V
RV1 220
DC OUTPUT LEVEL
RV2 3·3k
R10 4·7k
+22V
VT1
0V
COMBINED OUTPUT
1SKT4
MR1
+0·6V
VT3
-13·5V
R4 11k
R5 12k
R2 56k
R6 22k
R7 9·1k
+0·7V
VT4
-12·5V
R8 10k
R9 18k
MARKER OUTPUT
1SKT3
ON
SC
MARKER
OFF

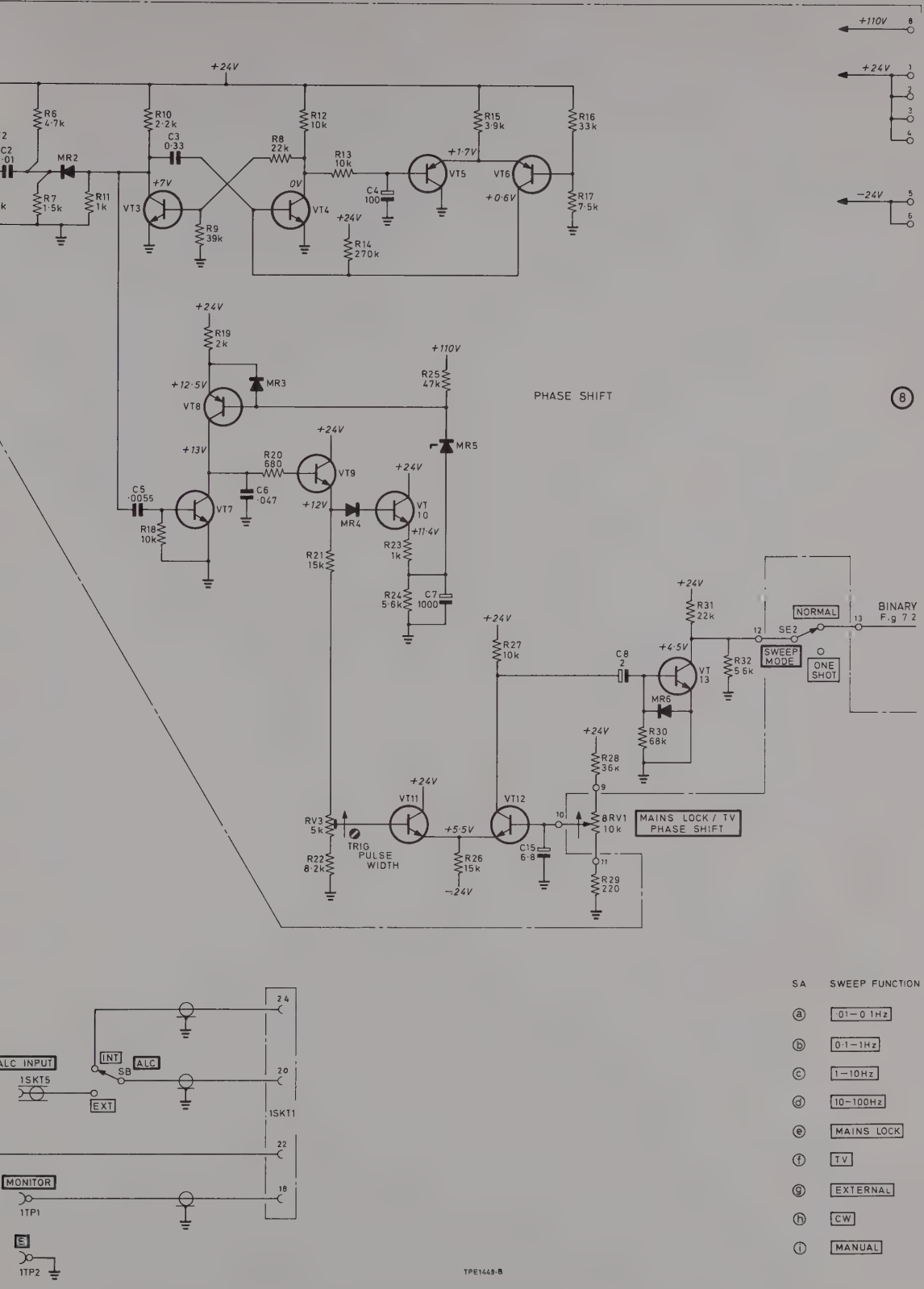
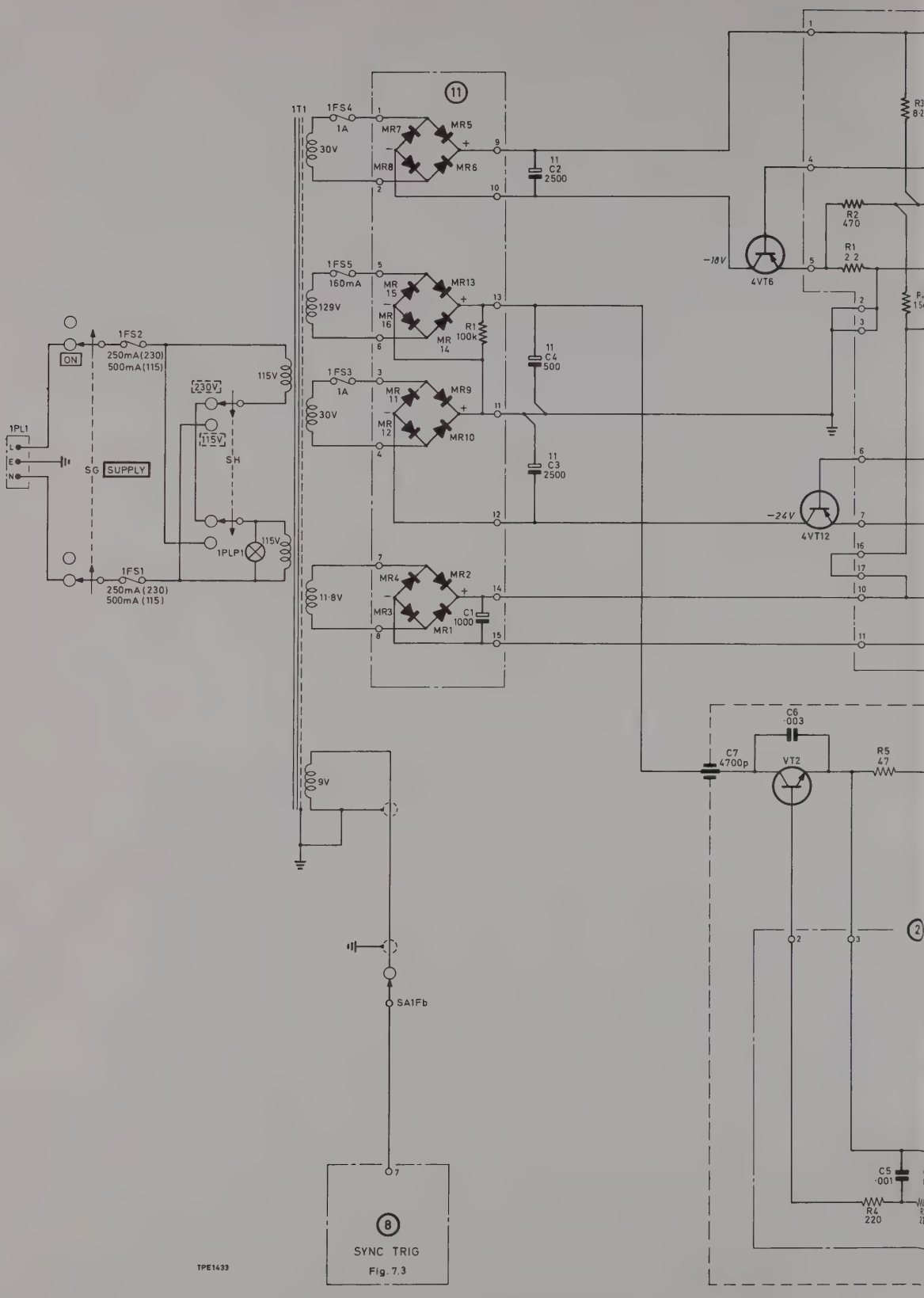


Fig. 7.3 Circuit diagram— sync separator and phase shift, external drive and marker adder


1T1
1FS4
1A
30V
MR7
MR5
MR8
MR6
11
C2
2500
1FS5
160mA
129V
MR 15
MR13
MR 16
MR 14
R1
100k
11
C4
500
1FS3
1A
30V
MR 11
MR9
MR 12
MR10
11
C3
2500
1FS2
250mA(230)
500mA(115)
ON
115V
230V
115V
SH
1PL1
L
E
N
SG
SUPPLY
1PLP1
115V
1FS1
250mA(230)
500mA(115)
7
MR4
MR2
11·8V
MR3
MR1
C1
1000
9V
SA1Fb
7
8
SYNC TRIG
Fig. 7.3
TPE1433
1
4
5
2
3
6
7
16
17
10
11
12
13
14
15
R3
8·2
R2
470
R1
2·2
−18V
4VT6
−24V
4VT12
C6
·003
C7
4700p
VT2
R5
47
2
C5
·001
R4
220

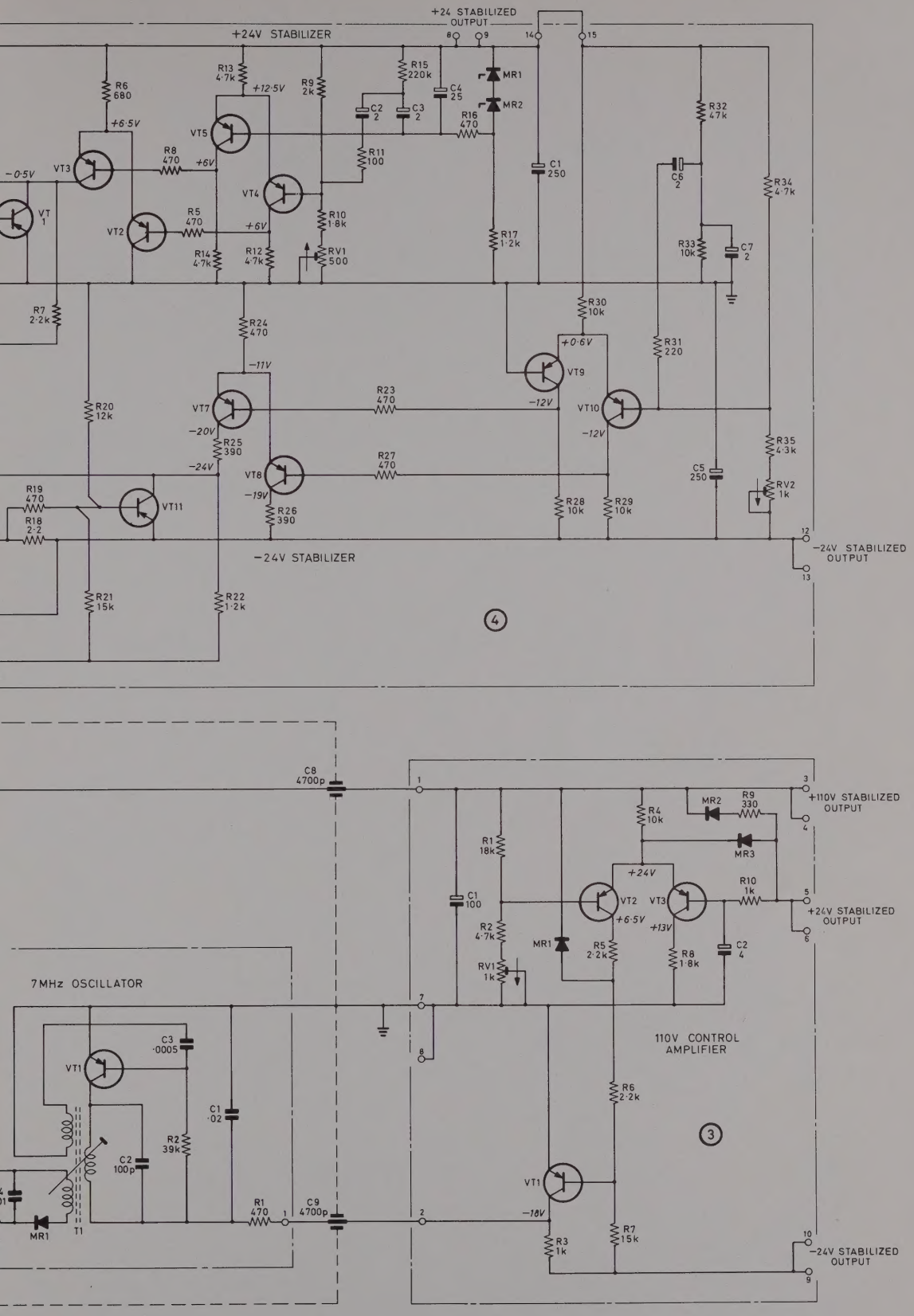


Fig. 7.4 Circuit diagram—power supplies

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